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THE NEW CENTRAL RAILWAY STATION AT SYDNEY, NEW SOUTH WALES.

The new central railway station now under construction at Sydney, New South Wales, is expected to cost nearly $5,000,000. At present the Sydney terminal of the government railways occupies a triangular area located between Prince Alfred Park and Regent St. on the east and west and Devonshire St. on the north. The terminal has a frontage on Devonshire St. The new terminal is simply an enlargement of the present terminal by extending it northward beyond Devonshire St. to Belmore Park as shown by the general plan Fig. 1. A view of the new station as it will appear when completed is given by Fig. 2. These two illustrations when studied together give a very clear idea of the lay-out of the station and its approaches. The following further description has been taken from a lecture by Mr. H. Deane, M. Inst. C. E., to whom we are also indebted for the drawings from which our illustrations have been prepared. Mr. Deane is Engineer in Chief for Railway and Tramway Construction, Department of Public Works, New South Wales:

GENERAL DESIGN OF STATION.—A great amount of attention has been devoted to the treatment of the front and west sides, and there is an addition of a wing on the east side. The tower, which will be situated near the northwest corner of the station, will be a commanding feature. It will be 250 ft. high from the ground level, and will be provided with a clock which will be visible from most parts of the city. The space enclosed between the wings of the building, and which is covered by the main roof, includes the assembly platform, 72 ft. wide, five docks with three roads each, and intervening platforms. Outside the building, on the east side, some lines will be laid which can eventually be extended into the city, should that work be authorized by Parliament.

It is intended that the accommodation for the public shall be specially commodious. It will be of such a character that it will not only be suitable and sufficient for many years to come, but it has been architecturally designed so as to be an object of admiration to visitors. A special feature of the Central Station design is its assembly platform (or, one might say, assembly platforms) because for the passengers leaving by train there is a wide covered space to the north of the main building, which to a smaller extent serves the same purpose as the larger one, situated between the two wings of the building. This latter is 348 ft. long and 72 ft. wide. The booking hall will, in accordance with modern practice be of a large size, namely, 110 ft. long by 54 ft. broad by 36 ft. high. Waiting rooms will be provided both for ladies and gentlemen.

The baggage room, situated at the northwest corner, is 72 ft. by 58 ft., and is convenient to the cab arrival platform. Two large lifts are provided in which the baggage is taken to the basement to be distributed through the subways and up the lifts to the various platforms.

FIG. 2. PERSPECTIVE DRAWING OF NEW CENTRAL RAILWAY STATION AT SYDNEY, NEW SOUTH WALES.

On the other side of the arched opening to the platform, and next the baggage, is the cloak room, 118 ft. by 40 ft., fitted up specially for the ready reception and delivery of parcels. Lifts are provided for the reception and delivery of goods to large stores in the basement. At the south end of the west wing of the main building is situated the main parcels office, 278 ft. by 50 ft., two stories high with basement, the top floor will be used for offices. Here special facilities will be provided for parcels inwards and outwards; there is a separate road, 40 ft. wide, for inward and outward traffic, with all the necessary raised platforms, &c.

A few words may now be said about luggage-conveying. Some years ago, overhead systems of conveying such as Aspinall's were viewed with favor. In the present station instead of doing the operation overhead, the levels permit of its being carried on underground by means of subways and lifts at suitable points. The position of the subways and platform lifts are shown on the plans, and the facility with which luggage can be transferred must be apparent. The mails, for which special accommodation has been provided in the southwest wing, will be taken to and dilvered from the vans in a special subway. It has been arranged to give the postoffice accommodation for transfer of mail, and the railway ambulance will be also accommodated.

There is one important particular in which our Sydney station differs from most of the terminal stations in the old country, and that is the absence of a cabstand under the main roof to meet the arrival trains. It has been usual to include such a provision, and it will be remembered that in the Park St., St. James Road and original Benevolent Asylum plan such a cab road was shown. The matter was one of very serious consideration by the Station Advisory Board and by the Railway Commissioners, and it was eventually decided that, owing to the exceptional facilities given to passengers and the handling of their luggage, the orthodox cab-road was not so great a necessity, and moreover, that being the case, it was considered desirable that the building should be kept entirely free from the smell, which the standing of horses under the roof must certainly involve.

ROOF.—It used to be thought that great advantage would be derived from having a station roof in one span without intermediate supports. It certainly makes it easier to lay out your station where it is not possible to arrange everything symmetrically. If the roads and platform can be symmetrically arranged with regard to the centre it does not as much matter, because a line of posts along the middle of a double platform is no detriment. The platform has generally to be divided down the middle, as passengers may be arriving on one side and departing on the other. Examples of English single span roofs are as follows: Charing Cross, 170 ft.; Cannon St. station, 187 ft.; St. Pancras, 240 ft. The latter was built to a bold and novel design and was the widest clear-span roof for a long time. The Jersey City terminus in America has a slightly larger span, namely 256 ft.; but the Philadelphia station has a clear span of about 307 ft. This roof was finished about ten years ago. A very good compromise is effected by placing two lines of intermediate pillars, as in our design, and still avoiding the disadvantages of valleys and throwing off the water to the two sides. The roof has a finer appearance than when cut up into three single roofs with their own ridges and valleys. This method of treatment I first observed in St. Louis, in 1894, but it may have been adopted before that. The same principle is carried out in the Boston roof. The central station roofs, as designed, consists of one central span of 198 ft., and two side spans of 75 ft. each, giving a total of 348 ft.

I believe that our Sydney roof will present a very fine appearance when finished. It should far surpass the roofs at St. Louis and Boston already mentioned, the curves of the arching and framing will be more elegant. It may not be as cheap, but it will be much more artistic.

The design of the roof necessitated very close and careful study. There is a good deal of groining in the roof over the Assembly platform, and the calculation of the stresses to which each member is subjected, under varying conditions of temperature and wind pressure are throughout the whole roof very complicated. It is important that there should be left no possible chance of any serious mistake in the calculations, and risk to the public and the public property, were there undue weakness to any part, must be avoided. I therefore considered it expedient, although entirely convinced of the competence of the officers under me, to recommend to the Minister that Professor Warren should be asked to assist in checking the calculations, and this was agreed to.

PLATFORMS.—The British practice with regard to platform heights originated that of Australia. It is to put their level 2 ft. 9 ins. to 3 ft. above the rails. Our platforms are 2 ft. 9 ins. above the rail at the edge, and are higher at the back. This is far the most convenient way, for passengers can enter and leave their car with comfort.

The new station possesses 13 platforms, each one of which is long enough to take the longest train yet run, and still longer trains might be placed in each dock if the locomotive is allowed to stand clear beyond them, a condition of things which is not allowable in the present station.

The new station contains the following:

	Feet.	Feet.
No. 1	715	715
" 2 and 3	593	1,186
" 4 to 13	702	7,020
Total		8,921

These figures, however, are very far from representing the actual capacity of the two stations, as the conven-

lences and readiness with which trains can be handled are vastly greater in the new one. No sooner will a train arrive in the station than a new locomotive can be run in from a refuge siding and coupled up, and as soon as the passengers are discharged, it will be ready to go out again. Moreover, much more work can be got out of the locomotives, and it will be seen that at a time when the intensity of traffic is greatest there is no need for idle standing in the dock, but the arriving locomotives can be shifted at once by means of the traverser on to the middle road and run out of the station to the shed, or otherwise to the refuge siding, where coal and water can be supplied to it, and so prepare it for the next trip.

The platforms on the new station are arranged to give about 15 ft. clear width to each adjacent road, and the double platforms are therefore made a little over 50 ft. wide. The side platforms have been arranged to give a width of 20 ft. To meet the desires of the Railway Commissioners, each of the five train docks under the main roof has three roads. The middle road has the double purpose of either serving as a road for running the engine out by on arrival, or if this is not required, and in the use of quick suburban traffic when the trains are being handled rapidly and there is no necessity to run the locomotive out before the train leaves, the third road may be used as a store for carriages.

At the ends of all these treble road docks traversers (transfer tables.—Ed.) will be provided. They take up less room than cross-overs, as very little more than 50 ft. is thus taken up, namely, the length of an engine and tender. If cross-overs were used, this length would have to be increased to 150 ft., and the train, in order to avoid fouling, would have to stand so much further out from the buffer stops. Two single lines traversers will probably be required, one on each outside road, for it is clear that the roads should be left continuous up to the buffer stops, as it would be difficult sometimes to prevent a train dropping into the pit. The traverser can be worked by hydraulic or electric power with which the new station will be amply supplied, or, what is probably better still, by gravity and automatically. If the middle road is laid a few inches lower than the others, the loaded traverser, on the release of a catch, would run down and take up the middle position, and after the locomotive has run off, a balance-weight might bring it back to its original position. The most modern kind of buffer stop is the hydraulic, and this will be adopted at the new station.

One matter which has to be carefully considered, and which has not yet been decided, is the method of providing water for the engines on arrival at the refuge siding and while waiting for their next job. There are several methods available. One is, to have a series of water cranes direct from a main running across the yard. This method is as a rule to be avoided. The water column requires a pipe of 8 or 9 ins. diameter to supply it, and the opening and closing of the valve of such a large pipe means too great a fluctuation and strain on the main. Another way, and that commonly adopted, is to have a capacious tank at one corner of the yard from which the supply pipes to the water cranes can be run. This is a great improvement on the first method, as a comparatively small pipe always pumping will keep the tank constantly full, but the principle involves a great length of supply pipe of a large diameter. A modification of this has been suggested, under which a long narrow tank extending across the yard could supply the water columns without much length of expensive pipe. A third method is one that has many advantages. It consists of the use of umbrella tanks. This is a small overhead tank, the water column acting as a pedestal to contain a tender tank full. When the engine comes alongside, the tank is discharged rapidly into the tender. After this, and before the next locomotive comes up, a comparatively small pipe fills it.

Since the lecture, from which the preceding extracts are taken, was written, considerable progress has been made in the construction work. A letter from Mr. Deane summarizes this progress briefly as follows:

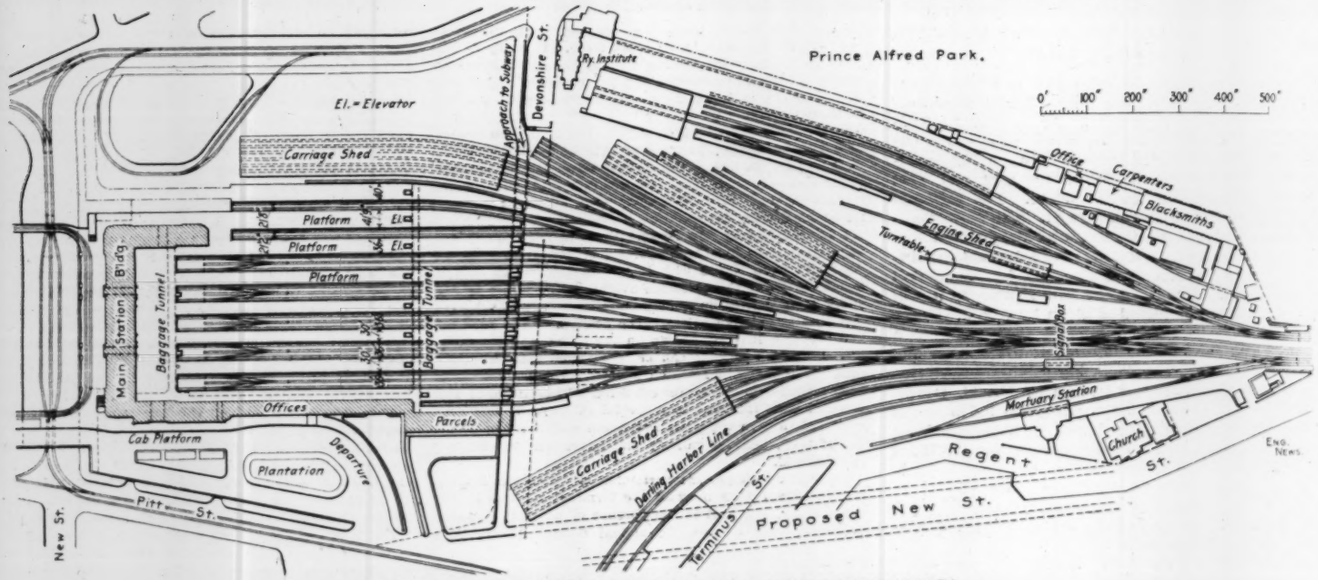
Since the delivery of the lecture, the erection of the station and approaches has been put in hand, and considerable progress has been attained. Owing to delays of a financial character, the advance has not been so great as might have been hoped, but still a considerable amount of work has been done. The first step to take was to acquire possession of the land, and raze the existing buildings on the site.

The foundation stone was set at the corner of Pitt St., New Belmore Road, by the Minister of Public Works on April 30, 1902, since which time the masonry and brickwork have been pushed on, and they have now reached platform level; a further memorial stone duly inscribed was laid at the base of the tower by the Premier of New South Wales during last year, and the erection of the first story walls has since been preceded with.

With a view to reducing the cost at the present time, the government have decided that the upper stories of the building, including the general offices of the Railway Commissioners, shall be left out for the present, and a temporary roof placed over the public offices, and also that the large roof covering the train roads and platforms shall be omitted at least for the present; the platforms to be covered by umbrella roofs only.

With regard to the cost of this work, the original estimate amounted to £561,600, but since that time the whole scheme has been much elaborated, resulting in the designs which have now been placed before you, and the cost will, when the whole work is complete with the stories and roof, very likely be double this amount.

Mr. Deane also states that contracts have been awarded to Mackenzie & Holland, Vulcan Iron Works, Birmingham, England, for the installation of a complete electro-pneumatic signalling and interlocking system.



CENTRAL RAILWAY STATION AT SYDNEY, NEW SOUTH WALES.

THE STADIA-INTERSECTION METHOD FOR TOPOGRAPHICAL SURVEYS.*

By L. E. Ashbaugh.†

The preliminary survey, map and report forms the usual beginning to any engineering project. Sometimes a very brief survey and report will suffice, while at other times a very thorough investigation must be made. It is not often, however, that the survey will require exact measurements and contour elevations, and it is for such work as will permit the use of the stadia, and of certain measurements being taken from the map by scale, that the methods given in this paper have been developed. The special use to which this stadia-intersection has been put is the investigation of the meandered lakes or lake-[illegible] Iowa. It was necessary to make a report, including showing the present condition of each lake, especially noting the extent, depth of water, shores, surrounding lands, with special reference to the low areas, [illegible] and other physical characteristics. This report would serve as a basis for a decision as to the maintenance [illegible] drainage of the lake.

The method of running base lines by stadia and [illegible] intersections to important points around the lake was developed during the past summer. While little [illegible] really new has been used, it is believed that these [illegible] should have more general use in our preliminary [illegible] At the beginning the stadia method of surveying was followed, but the reading of vertical angles was abandoned after one day's trial, and the contours have been sketched in by eye, it not being essential that exact elevations be taken. The boundaries of the lake and of the surrounding low land are carefully located, thus giving the two most important contours, and the surrounding hills, ravines, etc., can be sketched in with sufficient accuracy to give a good idea of the topography.

A transit with adjustable stadia wires has been found most convenient, the wires being set to "stadia constant equals 100," measurements usually being made in feet, but sometimes in retracing old government lines, chains are found most convenient and the wires are set to read chains. A variation plate on the transit is also useful in checking asimuths by needle readings. On this work a flexible leveling rod, 12 ft. long, was used, it being placed on a pine board, 1 × 4 ins., 14 ft. long, by means of thumb tacks. An error in these rods is that they stretch, and furthermore this error is not uniform. A small graduated steel tape was used to insure the proper placing of the rod on the board.

The plotting of all notes was done in the field, and for this purpose a drawing board about 16 × 24 ins. would be used. All plotting was done on 14-in. paper protractors, the drawing paper sheets being about 16 × 20 ins., with the 14-in. circular protractor imprint. The paper found most convenient is that supplied by the Keuffel & Esser Co., with numerical markings of the divisions omitted, as it is frequently advisable to have the zero or south point at the side of the sheet instead of at the end.

No flag poles were carried, lath and cloth being found more satisfactory as well as economical, when wages of flagmen are considered. Furthermore, if the lath were nailed to a fence post, or placed firmly in the ground, it was pretty certain to remain in position for some time, at least during the time of the survey, unless an inquiring cow or mischievous farm hand would come along. Three colors of flags were commonly used, viz.: white, red, and blue, the material being cheese cloth, cut into pieces about 8 × 12 ins. For short sights and for those of minor importance, single flags were used, and these would be on single length laths. The ordinary flags were of two colors and were made up in groups of six, each group having the six different combinations possible with the three colors. These "double flags" were usually of "double length lath," or 7 ft. high, two lath being spliced. Frequently a tri-color was used on an important point, and for special locations where a high flag was necessary, four or five laths would be spliced and lath bracing used to hold the same in vertical position.

Before going into the field the protractor paper would be divided into squares representing quarter sections, proper allowance being made for fractional sections if the

*Paper read before the Western Society of Engineers, March 15, 1905.

†Iowa State College, Ames, Ia.

lake crosses a township line. This work is done as an assistance to the draftsman, since in plotting only the most important objects as noted on the ground, he may miss a section line or quarter line which may be scarcely distinguishable, unless his attention is called thereto by his map. This outline also serves as a check on the plotting. For ordinary lakes a scale of 1 in. to 800 ft. has been adopted, while for small lakes the 400-ft. scale is used. For plotting meander lines, the scales of 12 chains or 6 chains to the inch may be very conveniently used on the respective maps, 800 ft. and 12 chains being approximately equal.

The method of procedure in the field may be shown by using a practical illustration, for which the work on Four Mile Lake, near Estherville, Ia., is chosen. A copy of the field sheet is herewith presented. This sheet represents only the field practice, a tracing being made later in the office, showing section lines and numbers, topographical symbols as needed, etc. The highways shown on the map are on section lines, thus indicating an area under survey of about 1½ sq. miles.

SAMPLE OF FIELD SHEET USED IN STADIA—INTERSECTION SURVEY.

Station 0 is situated at a fence corner, from which point a stadia reading was taken to the fence corner to the north (at the section corner) to obtain position of station. Azimuth was taken by observing the fence line which could be seen for over a mile to the north. Station 0 was chosen because it offered a good connecting point between the section corner and Station 1, at the north end of a high ridge near the shore, from which point excellent sights could be had to the prominent points around the main part of the lake. As Station 0 was on high ground, even though back from the lake, it commanded a good view of the surrounding country, and the instrument was kept at this point until flags had been set on the south side as far as Station 6 and on the north side to Station 7. The field book shows that 16 sights were taken from this point. For rapid work three men can be used at the instrument, the observer, the recorder and the draftsman. As a reading is called, the recorder notes the same, and the draftsman at once plots the line, using his triangles on the protractor to get azimuth, and carrying the same to the located station on the map. From a station such as this one, he soon has a number of radiating lines, and to avoid confusion he marks on the lines the number of the "sight point," or more frequently the color of the flags. This is shown on the map of the west end of the lake, where from Station 5 the rays are marked, as B/W to indicate a blue flag above the white one.

The distance 0-1 was read by stadia, and as the sight was long it was taken in two parts, from 0 to a "halfway point" on line between the stations, and from 1 back to the same point. In reading distances the lower stadia wire was set on an even foot and the half distance was then read and recorded. The total distance was then read and recorded and the check noted.

From Station 1 azimuths were read to all visible flags, some of which indicated future stations to be occupied, as 2, 4, 5, 6 and 7, stadia distance being read to 2, while many sights were taken to flags set along the shore line, as in bays or on points or back to some elevation. (The field sheet does not show all sights taken.) Flags were also set on fences, especially at corners, while a common procedure for locating fences was to take sights to the braced posts at the corners, indicating both in the note book and on the map the direction of the fences. For illustration, note the fence corner east and south from 2, the ray being indicated by "E and N," meaning fence east and north.

The drafteman's methods for locating these points is as follows: From 0, a blue, red and white flag on the north side of the lake has been located, and the ray drawn and indicated by the symbol B/R/W. At 1 the observer sights on a flag, calling out "blue, red, white, on north shore" and gives the azimuth. The draftsman at once plots the ray from 1 to intersect that from 0, thus giving the point. This would be checked from one or more later stations.

On the survey used in illustration, the stadia base line was run between Stations 0-1-2-3 at the east end of the lake. Stations 4, 5, 6 and 7 were thus carefully located by intersections, avoiding small angles as far as possible, but to insure accuracy a stadia check base was run from 5 to 6, at the same time that 5 was occupied. The instrument was oriented by observing 1, 2 or 3 (5 having been set after 0 had been left), and azimuth and distance were then read to 6, both of which checked accurately with the plotting from former stations. It was found unnecessary to occupy 6, as 5 and 7 gave all the details for the west half of the lake. The southeast corner of the section was located by sighting on the chimney of a school house, from which point the distances to the road were obtained by pacing. The direction of the highway along the south was given by locating a windmill west from the school house.

The instrument work on Four Mile Lake occupied one day. The draftsman found time to sketch in the territory to the east and part of that to the south of the lake, and on the following day he completed his map. With a sketch indicating the shore line and flags, one of the party took a boat and made the necessary soundings. Not all of the detail work was done by intersections, though this was the favorite method, the stadia rod being carried to many points within reach from the stations. Windmills were found to be the most useful check points on many surveys. Islands were frequently located by reading azimuths of lines tangent to their shores. Bays and points were thus commonly located, although flags were often used, especially at important points on irregular shore lines.

A brief reconnoissance by the chief of the party is of great service in outlining the method of work on each lake. Time will be saved if he can go over the entire area and set the important flags before any instrument work is begun.

On one lake it was required to locate with greater accuracy than usual the soundings over an area of deep water. Being near the shore a station was located from which stadia distances and azimuths to the boat could be taken, the rod being observed at the time of making the sounding. This method was found to be rapid and efficient.

The procedure known as "resection" on plane table work was frequently used in locating a new station. To illustrate, suppose that on Four Mile Lake Stations 0 to 5 have been located and occupied. While the instrument is still at 5 it is found that occupation of a station on the point on the north of the lake is desirable. Set a flag on this point (Station 7 on the actual survey) visible from 5 and from at least one other point previously located, and visible from two points if possible. Of course, on all this work, angles less than 30° or over 150° would be avoided. From 5 take azimuth on the new flag (No. 7). As another azimuth is required, such could be found by going back to 3 or 1 or other visible station, and from there read the new azimuth. To avoid this work just mentioned, occupy the new station (No. 7) at once, orient the instrument by a sight on 5, read the azimuth to another station or flag which is visible, as 1, and plot the azimuth backward from 1 to give the new station at the intersection of the rays from 5 to 1. A check should be taken on another point previously located.

The needle was read as a check on azimuth to all stations and to many other important points. The notes kept were very simple, being station (×) or sight point (S. P.) numbers, azimuth, needle, distance (the half distance being recorded in small figures in upper part of space), and description. The description should give all necessary data as to flags, fences and other objects, their color, position, direction, etc.

The method of intersections from stadia base lines has proved to be very efficient and rapid in securing results desired on these surveys. By careful choice of transit points on elevated ground, intersections can frequently be taken to cover a large area, thus rendering an easy solution to the making of the map. The use of the protractor paper in the field has also been found to be a great service to the draftsman. No claim can be made to new discoveries on this work. But there has been developed a high efficiency as the result of a careful combination of the simple methods of surveying by stadia, plane table, and triangulation, together with a little ingenuity and common sense, that the method may be adapted to the problem. It is believed that these methods can be extended to preliminary surveys for many purposes where the map forms an important feature of the investigation.

ARTESIAN FLOWS FROM UNCONFINED SANDY STRATA.*

By Myron L. Fuller.†

A peculiar type of artesian flow, which is sometimes encountered by engineers and others in their investigations of the water resources of regions of prevailingly sandy materials for city or town supplies or other purposes, is that taking place from uniform or approximately uniform sand. Defying, as it apparently does, all commonly recognized requisites of artesian wells, it presents a problem of unusual interest and one which at first sight appears difficult of solution.

The essentials for artesian flows, as defined by Prof. T. C. Chamberlin in his treatise on artesian waters in the Fifth Annual Report of the U. S. Geological Survey, are a *pervious bed* lying between *two impervious beds*,‡ and sloping so that its outcrop is at a height greater than that of the surface at the well, adequate rainfall, suitable outcrop and absence of leakage being assumed.

The requisites as defined above, the most essential features of which are the impervious confining beds and the inclination of the strata, have been almost universally accepted by writers on artesian waters, but recent investigations, some of the results of which are here presented, have shown that true artesian flows may take place where both of these conditions, supposedly indispensable to flows, are absent. In fact, sands which are pervious throughout and which are horizontal, will often when penetrated yield flowing wells.

EXAMPLES ON LONG ISLAND, NEW YORK.—In an investigation of the water resources of Long Island, New York, conducted by the U. S. Geological Survey in cooperation with the Commission on Additional Water Supply for Greater New York, a study was made of the ground water near the base of certain high bluffs bordering the deep narrow depressions occupied by the bays of the north shore. The materials in which the depressions are cut consist of gravels and sands, largely the latter, no clays or impervious materials usually being present. They are essentially horizontal and form an imperfect terrace about 200 ft. above sea level, as shown in the accompanying profile, Fig. 1.

The sands, even the finer varieties, were invariably pervious, and the water table appeared to exhibit in the main the regular curve characteristic of uniform materials, although slight irregularities, due to varying coarseness, doubtless exist. Notwithstanding the permeability of the sands, wells penetrating below the water table at points near the base of the bluffs obtained flowing water. Mr. A. C. Veatch, who investigated the problem for the U. S. Geological Survey, decided that the occurrence of flows depended upon slight differences in the degree of porosity of the sands which, however, were in all cases pervious throughout. Beyond establishing that a slight difference in

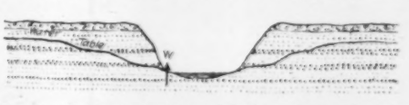


Fig. 1. Typical East-West Section Across the Bays on the North Shore of Long Island, New York, Showing Horizontal Stratification of Beds, Form of Water Table, and Position of Flowing Wells.

*Published by permission of the Director of the United States Geological Survey.

†U. S. Geological Survey, Washington, D. C.

‡The italics are those of the present writer.

porosity was sufficient to determine an artesian horizon,* however, nothing definite was discovered as to the differences in texture necessary to give rise to flows. In a way, the conditions are in harmony with a part of those outlined by Chamberlin, the finer materials, though entirely pervious, opposing the passage of water to a greater extent than the coarser material. Pressure, however, is readily communicated through the sand, even where there is much resistance to the movement of the water, and as the well pipe affords less resistance to the upward passage of the latter than that presented by the finer sands, flows take place.

EXAMPLES IN MICHIGAN.—During the summer of 1904 an investigation of the waters of the drift of this State was undertaken by the U. S. Geological Survey, during which 300 or more flowing well areas deriving their supplies from the glacial deposits were studied. One of the most interesting features brought out was the occurrence, as on Long Island, of flows from wells sunk wholly in sand. The topographic conditions are similar to those in the latter locality, and the materials consist of broad valley deposits, or of terraces or plains of sand, above which rise higher moraines or other glacial deposits. The wells are almost invariably located at the base of the slopes of the latter, where they merge into the lower plains. Commonly they penetrate more or less clay, but numerous cases were reported where only sand was encountered. It is the flows from the latter which are of special interest.

In many instances it is probable that more or less marked differences in texture exist in the sands of the wells, giving rise to the flows, as in those described on Long Island, but in other cases it was established that flows could be obtained where the sand was of so uniform a texture as to present no recognizable difference in the size of the grains. It was further found that such occurrences were not isolated, but of widespread distribution, the flows apparently being due to some cause other than difference in texture, depending, in fact, on a seldom recognized but widely prevalent type of artesian conditions.

The cause of these flows is probably to be found in the arrangement and shape of grains of sand. All the materials from which the flows of the nature described are obtained are stratified, in other words, were deposited as layers, which, though composed of grains of approximately uniform size, were nevertheless laid down successively one over another as horizontal laminae. It is characteristic of this process to develop conditions more favorable to the transmission of water along the laminae than across them, this being due in part simply to the lamellar arrangement. There is, however, another factor present; namely, the irregularity of the shape of grains, that has probably had considerable influence in regulating the flow of water through the sand. In sediments such as gravel and sand, the particles, no matter how uniform their size, are seldom symmetrical in shape. One axis is almost sure to be longer than the other (Fig. 2), and when deposition takes place there is a strong tendency of the grains to arrange themselves with the longer axis horizontal and with the grains overlapping each other to a greater or less extent like the shingles of a house, though of course far less perfectly (Fig. 3). Under such conditions it is clear that, although the material is perfectly pervious and may hold large amounts of water, the passage of water across the stratification will be much more difficult than along the lines of bedding. When a well enters such material it affords an easy upward path for the water as compared with the passage across stratification of the character described, and a flow will often result.

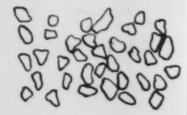


Fig. 2. Shapes of Grains of Sand. Drawn from Photograph.

Fig. 3. Grains Similar to Those Shown in Fig 2, Showing (Exaggerated) Overlapping.

*Science, N. S., Vol. 19, pp. 795-796, 1904.

The bearing of this peculiar type of flow on the water supply problems of individuals, or of small towns in the deeply gravel or sand covered regions of Michigan, Wisconsin and other of the northern states is important. It is no longer to be assumed that impervious confining beds are necessary to the flows which are so highly prized in many regions. In fact, if the topographic conditions are such as to give the necessary head, flows may even be obtained in uniform sands. In the states mentioned it is rare that a well located at the base of any high elevation of sand, gravel or other materials fails to obtain flowing water, the exceptions being generally those wells penetrating nothing but clays. Pure ground water supplies are awaiting development in hundreds of small villages in these regions. Most wells obtain flows at a depth of 100 ft. or less, while wells over 200 ft. deep are relatively rare. The flows are commonly confined to a strip along the base of the bluffs or slopes about a quarter or half a mile in width, but occasionally artesian wells are found at considerably greater distances from the highlands.

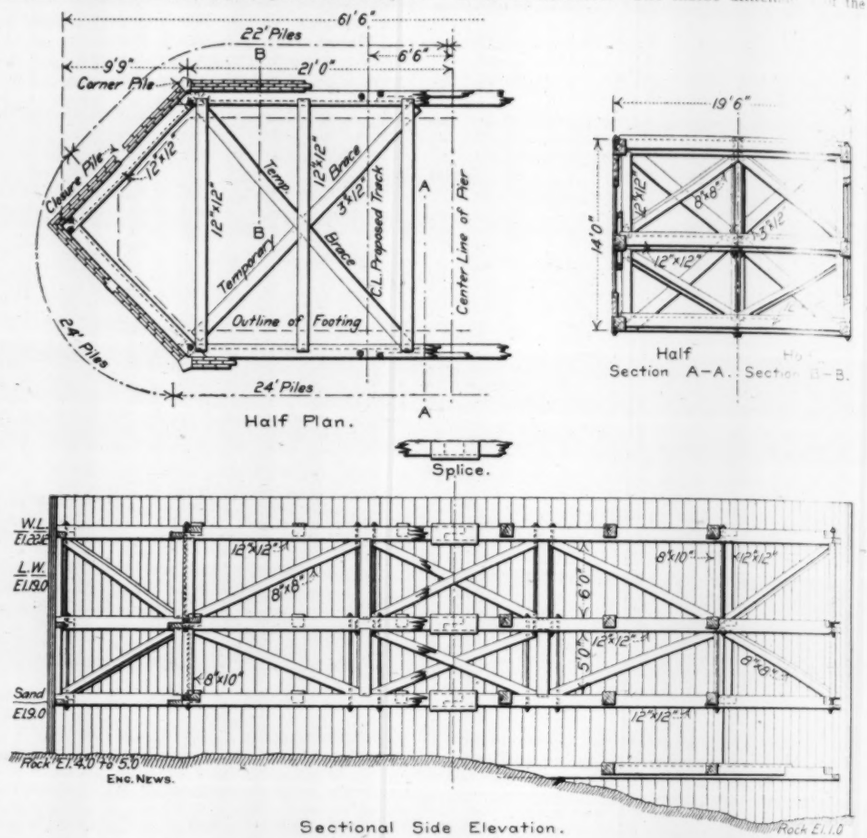


FIG. 1. HALF PLAN OF COFFERDAM FOR PIER OF NEW BRIDGE AT KILBOURN, WIS.; CHICAGO, MILWAUKEE & ST. PAUL RY.
C. F. Loweth, Engineer and Superintendent of Bridges and Buildings.

A LARGE CONCRETE PIER WITH A SHEET PILE AND CANVAS COFFERDAM.

By James C. Hain.*

In the early part of September, 1902, work was started on the foundation of a large bridge pier in the Wisconsin River, near Kilbourn, Wis., where the Chicago, Milwaukee & St. Paul Ry. crosses that river at the famous "Dells of the Wisconsin." The conditions were somewhat unusual, though not exceptional. The bottom of the river was ledge rock, dipping to the east and north (the latter up-stream) quite considerably. Overlying this was several feet of loose shifting sand, containing some loose rock. The channel was narrow, and confined between vertical rock bluffs for a long distance above. The current [illegible] very swift, averaging from six to eight mile[s] hour, and the changes in water level were [illegible] suddenly. The rock bottom averaged [illegible] vary 23 ft. below ordinary water level and [illegible] 18 to 34 ft. below high water. These were [illegible] 28 to conditions where a pier of about 60 ft. in [illegible] (including footings) for a double-track [illegible] was to be constructed. The inside dimens[illegible] of the cofferdam required were 19½ × 61½ ft. The length, however, included two pointed noses, as shown by the drawings of the cofferdam.

It did not seem necessary to construct a dam for the highest stage of water. The work was started late in the fall, as before mentioned, and was finished before the spring high water; and only occasional high water of short duration had to be contended with. It was considered best to build the top of the cofferdam about 3 ft. above the ordinary stage of water, and abandon the work if the water went over the top. The dam was only once completely submerged.

Double and single cofferdams were thoroughly considered; the conditions seemed less favorable for the double. The material in the river was very loose sand, and there was nothing to hold the outside sheet piling in place. The pier was so large that outside frames were out of the question without tying to the inside; the bolts could not be put in without the assistance of divers, and were undesirable because of possible leaks. Furthermore, filling for the space between the rows of sheet piling could not be obtained at the location, but would have to be handled by train and rehandled before placing. The single cofferdam largely eliminated these features, and was therefore decided upon, and its construction is shown in Fig. 1. A single row of three-ply sheet piling was used, made of 3 × 12-in. plank lapped so that a 3½-in. tongue and groove was made. Two-thirds of the planks were surfaced to a uniform thickness; the outside plank was undressed. The piling was spiked and bolted together as shown in the drawing. Countersunk bolts were used only in the bottom to be sure that the battering

*Engineer of Masonry Construction, Chicago, Milwaukee & St. Paul Ry.

on the rock would not crowd them apart. Though the top of the piling had the same tendency to separate, if not more, it seemed necessary to use bolts only as occasion required.

The general design of the cofferdam frame is shown in the drawing. It was weighted down with scrap rails and secured in place by two wire guys which were anchored to the rock on either side of the river, wire guys were used instead of rope to eliminate variations in length. One of the guys crossed the navigable channel, which necessitated weighting and sinking it so as not to obstruct pleasure craft, which was the only navigation in the river. The hold of these guys on the frame was changed as required to prevent interference with the driving of the sheet piling. No little care was needed in making these changes to prevent a movement of the dam. The difficulty was increased by the strong current. When the driving was finished, the guys extended around the lower end of the cofferdam.

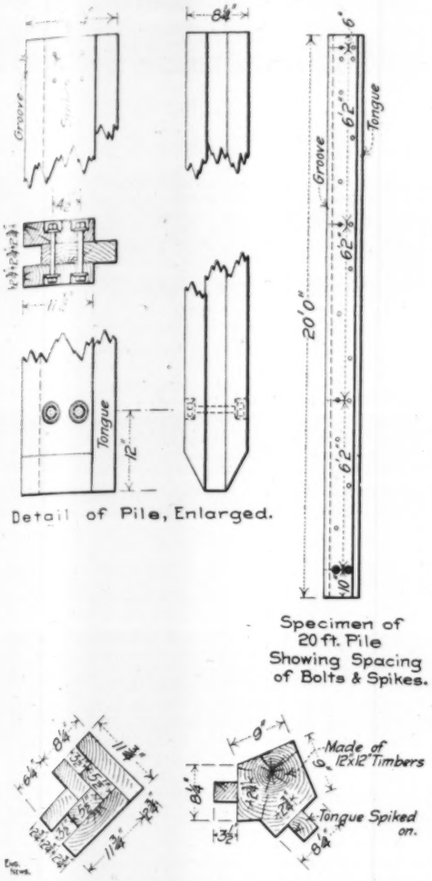

Groove
Tongue
Detail of Pile, Enlarged.
Specimen of 20 ft. Pile Showing Spacing of Bolts & Spikes.
Made of 12x12 Timbers
Tongue Spiked on.
Plan of Point Pile.
Plan of Corner Pile.

Fig. 2. Sheeting, Corner and Point Piles for Cofferdam.

A light land pile driver was used to place the sheet piling. No hammering was required to penetrate the loose sand; in fact, the sand disappeared from the location of the pier before the driving was finished, undoubtedly caused by the increased velocity produced by the obstructions. Great care was taken in driving, especially to have each pile fit snugly to the adjacent one, and after it reached the rock more light pounding was done in order to broom the ends of the piling, and thus make it fit more closely to the irregular rock surface. The latter pounding was not started, however, until the piles were all driven, for fear of displacing them. The piles were not beveled to make them draw, because what sand was left, if any, was so loose that it gave little resistance to the driving, and hence did not help direct the pile. However, they were beveled to conform to the slope of the bottom as nearly as practicable. The pile was also sharpened on both edges so the blunt end was about 1½-ins. across, as shown, so the driving would make them conform better to the rock surface. Both of these precautions greatly reduced the leakage at the bottom. The most serious trouble was with loose stones on the river bed, which sometimes necessitated taking out the pile, displacing the stones and redriving. The principal leakage was caused by these loose stones. The six corners had specially designed angles as shown. These were made watertight, then driven and securely fastened to the frame work. Driving was then done in both directions from the corners, and a closure put in about half way between. There were six of these closures, and the greatest care was used in designing, making and driving them, as upon them depended the success of the entire cofferdam. They were made to wedge in slightly. Fig. 2 shows the main, corner, and point piles.

The feature in this dam, which will perhaps bear special mention, is the canvas which was used around the outside, as shown in Fig. 3. It was made up in four pieces, so arranged that the lower apron laid flat on the river bottom for 8 ft. out from the dam, and the upper part extended above water level to prevent the water getting behind it. Some little difficulty was experienced in placing it because of the swift current, but with the outer edges weighted with sand bags and scrap rails, and by using rails suspended horizontally from ropes and moving them up and down the side of the dam, the canvas was placed. It was found desirable, however, to first sew the four pieces together. About 50 car loads of gravel was then placed on it. This completed the dam. The apron was of No. 2 duck, edged with ⅝-in. rope and having eyelets 24 ins. apart for attaching the apron to the cofferdam. The eyelets were so arranged that the load came on the rope edge.

Two vertical centrifugal pumps (one 6-in. and one 8-in.) were used to empty the pit. The leakage was most entirely around the bottom where the sheet piling encountered loose rock. Two seams in the rock also admitted water. The sides of the dam were dry enough to strike a match on. When the dam was finished, the leaks in the bottom were small, and the 8-in. pump was more than sufficient to keep the water down. This was an excellent record for so large a dam in such swift running water. The leakage perhaps would have been still less if the sand and rock had been removed from under the lower apron of the canvas.

We were convinced that in economy of material and labor, and ease of construction, this design greatly surpassed any other.

The pier was built entirely of concrete except 20 ft. of the neat work from a little below low water, which was faced with granite. The face stones were handled by derricks attached to both sides of the iron trusses of the bridge; these are shown in the view, Fig. 4. Another derrick on the dump handled the stone at the level of the track (top of the truss) and loaded it on push cars which were shoved down to setting derricks on the lower deck of the bridge, which was a highway. At that point the car was run on a turntable and placed at either derrick as needed. The concrete was mixed by machine at the level of the highway at one end of the bridge and dumped through the floor into a spout which can be seen in the views. This worked very satisfactorily, though the concrete was dumped a maximum distance of 70 ft. The delivery was easily directed to the location desired, and the concrete was deposited in perfect condition. The spout was cut off as the work progressed. The round noses for the pier are shown in two of the photographs and the completed pier in another. The concrete work was done in winter, which accounts for the use of reinforced rods, as shown in the drawing of the pier, Fig. 5. However, by taking proper precautions an excellent job was obtained.

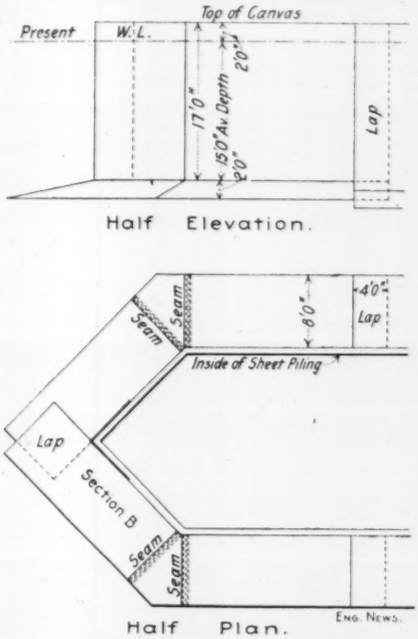


Fig. 3. Canvas Apron for Cofferdam.

On the Chicago, Milwaukee & St. Paul Ry. all masonry structures are built by the Bridge and Building Department with its own outfit and

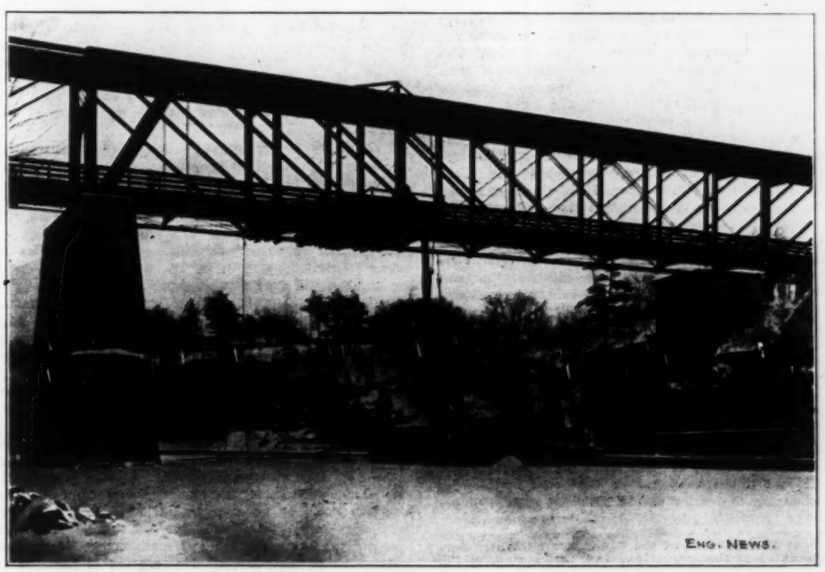


FIG. 4. DERRICK AND CONCRETE SPOUT ON OLD BRIDGE FOR CONSTRUCTION OF NEW PIER.

forces. Mr. C. F. Loweth, M. Am. Soc. C. E., is Engineer and Superintendent of Bridges and Buildings, and the writer is employed under him as Engineer of Masonry Construction.

RAILWAY WATER SERVICE.*

Much progress is being made by American railroads toward improving the character of the water that is furnished to locomotives. Many have found it advantageous to abandon wells that produced hard water, and secure a supply of softer water by constructing reservoirs to collect and retain surface water. Several railroads have erected water-softening plants during the past year. The last report contained a list of 27 American railroads having water-softening plants. This list is now increased to about 40. Several railroads that erected a few water-

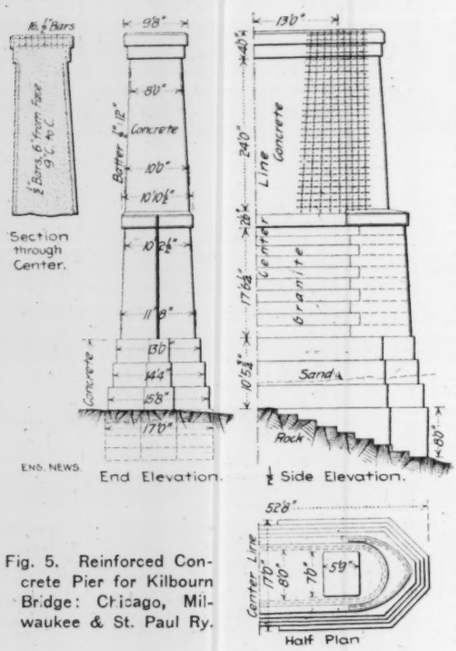


Fig. 5. Reinforced Concrete Pier for Kilbourn Bridge: Chicago, Milwaukee & St. Paul Ry.

softening plants, largely for experimental purposes, found the results so satisfactory that during the year they have erected additional plants. There seems to be no question, then, as to the beneficial results that can be obtained by using softened water in locomotive boilers, nor the necessity for softening hard water before using it in boilers.

WATER-SOFTENING METHODS AND PLANTS FOR VARIOUS CONDITIONS.

All natural waters contain certain solid matter in solution, suspension, or both. When this exceeds a certain amount, it causes trouble in boilers in one or more of three ways: 1, depositing scale in the boiler; 2, corroding the boiler and its fittings; 3, causing the boiler to foam. The first two can be corrected by treating the water with chemicals before it enters the boiler. The only complete known remedy for the third is to distil the water.

The kind and quantity of chemicals required to soften any water can readily be determined, by anyone conversant with the subject, from the figures showing the results of an analysis of the water. If the hardness is due to carbonates of lime and magnesia, the cheapest known chemical for removing it is common lime, and the cost of softening will be comparatively low. If the hardness is due, however, wholly or in part to sulphates of lime and magnesia, it will be necessary to use something else, and soda ash is the cheapest known chemical that can be used for that purpose. Many waters can be softened by the use of lime alone, and when such is the case, the operation is almost ideal, as nothing is added to the softened water, because the lime used for softening is precipitated along with the hardening matter that was in the water. When it is necessary, however, to use soda ash to remove the sulphates of lime and magnesia from the hard water, a by-product of sulphate of soda is left dissolved in the softened water. This sulphate of soda does not form scale in the boiler, but if allowed to concentrate in the boiler, it is liable to cause forming. It is, therefore, desirable that it be removed from the boiler by blowing off or changing the water in the boiler at regular intervals.

*Abstract of the report of the Committee on Water Service, presented at the annual meeting, in Chicago, of the American Railway Engineering and Maintenance of Way Association. G. M. Davidson, F. A. Delano, J. A. Barnard, A. McGill, C. A. Morse, R. S. Parsons, E. J. Pearson, J. C. Stuart.

COST OF INSTALLING AND OPERATING WATER-SOFTENING PLANTS, AND THE BENEFITS DERIVED FROM THEIR USE.

The cost of installing a water-softening plant varies in different localities, and, of course, depends largely upon the type and capacity of the plant. In general, it may be stated that a small plant having a capacity of, say, 40,000 to 60,000 gallons of water per 24 hours, may be installed for about $2,000; while a large plant having a capacity of 500,000 gallons per 24 hours may cost $10,000. The exact cost of plants of various types required to soften a definite amount of water in 24 hours can readily be ascertained from manufacturers of water-softening plants. The cost of chemicals required to soften a fixed quantity of any hard water can be figured from an analysis of the water. The cost of operating will vary according to cost of chemicals in the locality and also upon the efficiency of the apparatus. In most forms of both types of apparatus, the cost for labor is very little, as most of the water-softening machines on the market are automatic and simple, and require so little attention that the ordinary pumper can attend to them without neglecting his other duties.

The five American railroads that have gone into the matter the most extensively are naturally located in the west, where the water supply is much worse than in the east. Each of these has 15 or more plants in operation, and three of them are constructing additional plants. The information given by the officers of these five railroads in regard to the results from the use of softened water shows some of the benefits that have been obtained.

ATCHISON, TOPEKA & SANTA FE RY.—Most of the water-softening plants are located in western Kansas and Colorado. In this district, during December, 1902, there were 456 locomotive boiler failures from leaking and 16 from foaming. These were gradually decreased by the use of the softened water, until in December, 1903, there were only 68 failures from leaking and 48 from foaming—this particular month showing more failures from foaming than any month for two years, while in July, 1904, they had but 28 failures from leaking and 4 from foaming. The average for 12 months ending with July, 1904, was 55 failures from leaking and 16 from foaming per month; this against an average of 216 failures from leaking and 15 from foaming during the 12 months previous. The failures from leaking have decreased 74% since the softening plants were installed, while the failures from foaming have not materially increased. The experience has shown that just after the treatment of water begins, there is an increase of boiler expense, owing to the fact that the old scale becomes cleaned off by the use of the softened water, and this cleaning off of the scale hastens the time for the engines to go to the shop, but when they come out with a new set of flues they make a showing that is highly satisfactory—a new set of flues lasting an average of from 12 to 14 months, where before the water was treated they had to be renewed in from 6 to 8 months.

A comparison of the number of new locomotive flues issued for a year before and after the water-softening plants were installed indicates one of the benefits of softened water. During the year ending July, 1903, the Store Department issued 795,226 lin. ft. of flues, while during the year ending July, 1904, 685,289 ft. were issued, being less by 109,937 ft., notwithstanding the fact that the locomotive mileage for the latter year was 40,295,707 miles, while for the former year it was 39,932,405 miles, being an increase of 363,302 miles. To summarize: After the plants were installed, the locomotives made 363,302 miles more than the year before, and the Store Department issued 109,937 lin. ft. less flues than the year before. From these statistics regarding flues and locomotive mileage it seems certain that a saving was made, and this saving is attributed entirely to the use of softened water.

A statement of the wages of boilermakers, apprentices and helpers employed on the district where above failures were recorded, for 12 months from August, 1903, to July 31, 1904, shows a net decrease for that time of $7,000 over the corresponding 12 months of the year before. The average cost for chemicals and labor was 2.8 cts. per 1,000 gallons of water softened, the cost ranging at different plants from 0.32 ct. at the lowest, to 10.82 cts. at the highest, the next highest being 5.56 cts.

CHICAGO & NORTHWESTERN RY.—The Water-softening plants of the Northwestern line are located in Iowa, Minnesota and Illinois. The main line of the Iowa Division, extending across the State of Iowa from the Mississippi River to the Missouri River, a distance of 352 miles, is equipped with 17 water-softening plants, and, where water stations exist that are not so equipped, the water used is natural soft water. All the locomotives running on this division, therefore, are supplied with soft water. A portion of these 17 plants have been in operation two years, and all of them at least one year. After a year's exclusive use of soft water, the Master Mechanic of this division was asked by his superior officer to go over his records and state what benefit the use of softened water had been in the operation and maintenance of the locomotives under his charge. He reported in part, as follows:

I have the following figures which I desire to submit in testimony of the benefits we have derived from purified water. Our boilermaker force has been decreased as follows: In 1902 we had at Clinton and Boone an average of 36 boilermakers, costing $10.40 an hour, and [illegible] boilermaker helpers, costing $7.09 an hour; while in 1903, and thus far in 1904, we have had an average of [illegible] boilermakers at an average cost of $7.71 per hour, and [illegible] boilermaker helpers at an average cost of $6.70 an hour. This means that we have decreased the cost for boilermakers 25% and that we have decreased our boilermakers 0.1%. The increased compensation received by boilermakers makes the difference in the percentage of force employed and cost of same.

The decreased number of boilermakers, with the beneficial results from the treated water, together [illegible] enabled us to keep our engines in such condition [illegible] the number of engine failures has dropped off to a remarkable degree.

	August, 1902, to and including June, 1903.	August, 1903, to and including July, 1904.
Leaky flues	544	[illegible]
Leaky fireboxes ...	33	[illegible]
Leaky arch-tubes ..	6	[illegible]
Total	583	[illegible]

This gives a reduction of 79.4% in our failures due to leaky conditions in the above months. These improved results in engine failures in 1903 over 1902 have been made with conditions that show a heavier tonnage in 1903 than in 1902, showing that the engines were worked up to their full capacity, and even under these conditions made such an improvement.

The average cost for chemicals and labor was [illegible] cts. per 1,000 gallons of water softened; the cost ranging at different plants from 0.81 ct. at the lowest to 3.10 cts. at the highest.

SOUTHERN PACIFIC CO.—Most of the plants are in California. Some have been in operation since 1896, and the fact that at the present time they have 10 plants in course of construction indicates that the problem of water-softening is no longer an experiment with them. Their records and the comparisons that they have made at different times during the past 8 years show that the cost of boiler repairs has been decreased 50% by the use of softened water. The average cost for chemicals only was 4.4 cts. per 1,000 gallons of water softened, the cost ranging at different plants from 1.4 cts. at the lowest, to 7 cts. at the highest.

UNION PACIFIC RY.—These plants are located in Nebraska, Wyoming and Kansas. The Wyoming Division has a number of water-softening plants, and natural soft water is used to some extent. A study of freight train statistics before and after the improved conditions in water supply shows an increase in the average monthly locomotive mileage of 27%, an increase in gross ton miles per pound of coal of 7½%, and a decrease in cost of repairs per locomotive mile of 34%. The increase in gross ton miles per pound of coal and decrease in locomotive repairs is directly due to the better water supply, and the increase in the monthly locomotive mileage is largely due to the same thing, but cannot be entirely attributed to this one cause.

A better idea of the reduction in expense in locomotive repairs may be obtained from the following: There are assigned to this district about 8 passenger and 20 freight locomotives. The average life of a set of flues in passenger locomotives before the water was softened was 6 months; since softening the water, the average life is 2½ years. The average life of a set of flues in freight locomotives before softening the water was from 10 to 12 months; since then it is 2¼ years. Before the change in water, a great deal of trouble and expense were incurred because of tube sheets cracking between the holes, and occasionally a crown sheet was mud-burned. No troubles of this nature have occurred since using the better water.

The average cost for chemicals only was 1.3 cts. per 1,000 gallons of water softened, the cost ranging at different plants from 0.63 ct. at the lowest, to 2.55 cts. at the highest.

CONDITIONS UNDER WHICH THE INSTALLATION OF A WATER-SOFTENING PLANT WOULD PRODUCE SAVINGS.

It is conceded that it costs less to produce steam from soft water than from hard water. A railroad that operates its locomotives in a region where natural soft water exists, is saved much expense that a railroad that operates its locomotives in a hard water region is put to. It has become apparent to the officers of American railroads during the past few years that the quality of water used in their locomotive boilers should be improved.

About ten years ago a general attempt was made by railroads located in the middle west to do something to reduce the trouble caused by using hard water in locomotive boilers. This was accomplished to a limited extent by using soda ash and other chemicals directly in the boilers, and the relief for a time was quite marked, but with the continued growth of the locomotive boilers, and increased amount of steam required from them, it was found necessary to resort to some process of treatment by which the incrusting matter could be removed from the hard water before it was allowed to enter the boilers.

In general, it may be said that if a water is corrosive, it should be treated to remove the cause of its corrosive action. If it contains over 15 grains per gallon of hardening solid matter in solution, it will pay to soften it, no matter what this hardening matter consists of. If a water contains less than 15 grains per gallon of hardening matter, but this hardening matter consists largely of sulphate of lime, it will pay to soften it. If a water contains

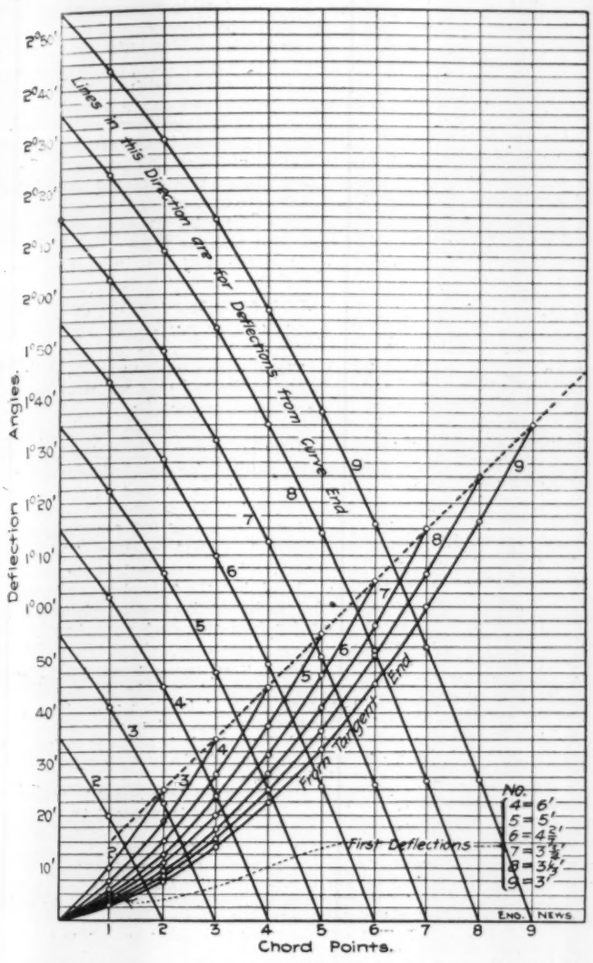


DIAGRAM NO. 1. DEFLECTION ANGLES FOR LOCATING SPIRAL CURVES.

Rule.—Make chord lengths = 100 ÷ degree of curve; then select any one of the 7 spirals given according to length desired.

Example: If the main curve be 4°
then the No. 2 will give spirals 50 ft. long,
" " 4 " " " 100 " "
" " 6 " " " 150 " "
" " 8 " " " 200 " "
etc.

Whole angle of a spiral = $\frac{N°}{2}$

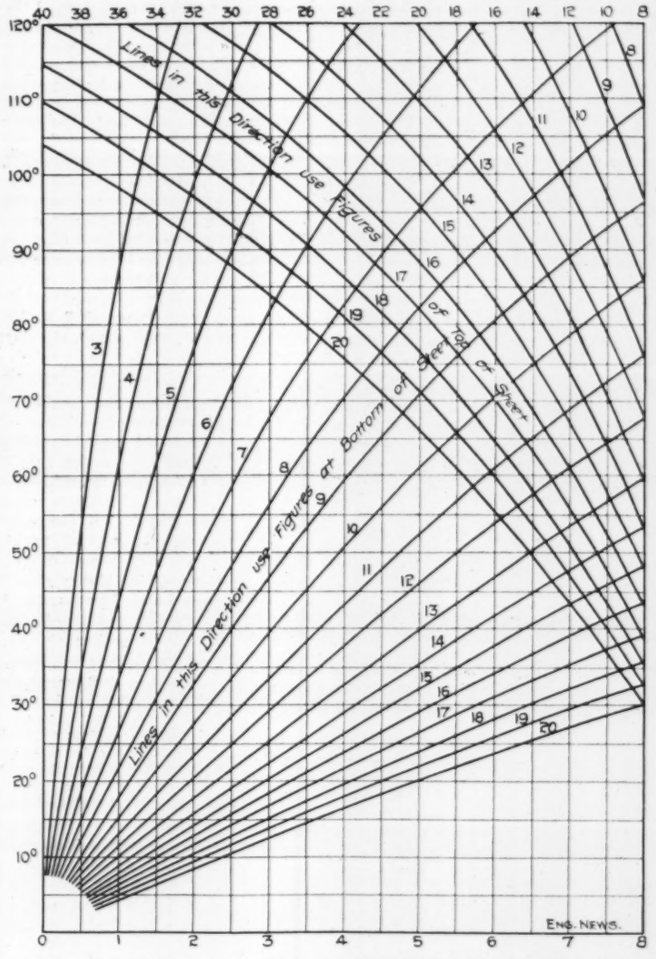

Lines in this Direction use Figures at Bottom of Sheet for Short Spirals
Lines in this Direction use Figures at Top of Sheet
ENG. NEWS.

DIAGRAM NO. 2. INCREASE IN TANGENT DISTANCE DUE TO SPIRAL.

Rule.—To half the length of spiral add the diagram quantity divided by the degree of main curve.

Example: Given a 6° curve for 75° to insert No. 18 spirals (which would be 300 ft. long). The line 18 intersects 75° at 19.6, which divided by 6 gives 3.27, which + 150 = 153.27.

50 grains per gallon of alkali salts, and also a large quantity of sulphates of lime and magnesia, it will not pay to soften it, as the resulting softened water would undoubtedly cause foaming.

European railroads have been softening water for many years. One European manufacturer of water-softening apparatus has published a list of some 2,000 users of his apparatus; another a list of about 1,200 of his plants, yet the natural water supply in Europe is no worse than that of America.

DIAGRAMS FOR SPIRAL CURVES.

By A. M. Haynes.*

The accompanying diagrams not only give a new and practical method of handling spirals, but shows some new features in the making of diagrams.

Diagram No. 1, Deflection Angles, is a very complete system alone. It is all that is necessary in the plain work of projecting true spiral curves that will blend uniformly from tangent to a circular curve. The engineer has nine different lengths to select from.

With his transit at the tangent end of the spiral, he deflects angles to each chord point, the deflection being found by following the line of his chosen spiral from the lower left hand corner of the diagram upward to its intersection with the vertical line from the given chord point.

With his transit at the curve end, he deflects angles found by following the line of his chosen spiral running from the bottom upward and to the left, until it intersects the vertical line through the given chord point.

If he runs his tangents to an intersection, from which P I he must measure the "tangent distance" to the ends of curves, he needs Diagram No. 2, which requires no explanation. If he wants external secant use Diagram No. 3.

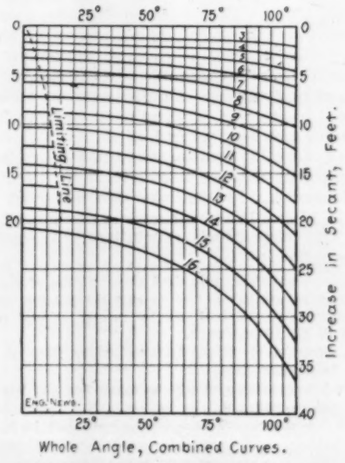


Diagram No. 3. Increase in Secants Due to Spiral.

Rule.—Divide diagram quantities by the Degree of Main Curve.

Example.—Given a 4° Curve for 62° to be eased with No. 10 Spirals. 10.3 ÷ 4 = 2.6.

If he wants chords, offsets, etc., diagrams may be prepared in the same manner, giving quantities always to be divided by the degree of main curve.

If N be the number of spiral, the first deflection from tangent is $\frac{30'}{N + 1}$.

This first deflection must be determined closely when a General Deflection Table is used, which is indispensable when the transit is set between the ends of spiral—a contingency hardly worth considering.

This General Deflection Table has been repeatedly published, and may be found in my "Curves of Civil Engineering," together with other rules and formulas illustrating the simplicity resulting in division by degree of main curve in obtaining all elements.

*37 South Lincoln Ave., Denver, Colo.

ANNUAL CONVENTION OF THE AMERICAN RAILWAY ENGINEERING AND MAINTENANCE OF WAY ASSOCIATION.

The sixth annual meeting of this Association was held at the Auditorium Hotel, Chicago, on March 21, 22 and 23. The attendance was large, and the sessions began early and ended late, but nevertheless the actual results were in some respects disappointing. It is very evident that the problem of the proper method of handling the proceedings of an annual meeting, with reports of a dozen committees to be considered, in addition to the transaction of routine business, has not yet been solved by this Association. Of 17 committees, 13 had reports, which had been printed and distributed during the past six

months. The other four made brief verbal statements or reports of progress. Of the 13 reports, 11 were considered and two were read by title. Three of these reports occupied the convention's time for four entire sessions; another session was devoted to a general and valuable discussion on wear of rails, and the remaining 8 reports were crowded (with some routine proceedings) into two sessions, the interest evidently being to at least have a record of acting upon the reports in some way or other.

At the opening meeting on the morning of March 21, a brief address was delivered by the President, Mr. Hunter McDonald, Chief Engineer of the Nashville, Chattanooga & St. Louis Ry. Some extracts from this, dealing with matters of special importance, are given herewith.

It has been our practice in the past to shun all discussion of devices and appliances which are proprietary articles or covered by patents. The reason for such a course seems to be the fear of advertising such devices. When it is remembered that nearly all the important improvements in railway appliances of recent years have been the result of the labors of men not connected directly with railroads, and that many patented and proprietary appliances are indispensable articles of daily use, it would seem that our position in this matter is incorrect. We should not hesitate to seek out and condemn the unworthy and to commend the meritorious. It is fully realized that such a course is strewn with pitfalls, but we possess the intelligence and integrity to avoid them. We have always shied at the word "standard," but it is harmless, and there is no other word in our language which comes as near the one we need as this one. Webster defines it as "that which is established as a rule or model by reputable authority, by custom or general consent." What we want is a word that stands for the best we know. What it represents may and will change from year to year, but the name will remain the same.

We should not refrain from approving or condemning any practice with respect to our work solely for fear that such action may eventually entail hardships on some roads. We are charged with the details of the physical construction and maintenance of our lines, and our first consideration is that of safety of the passengers and property committed to our care. Financial considerations, while not to be neglected, should be secondary.

The special committee of the American Society of Civil Engineers, appointed to consider rail sections, has reported in favor of taking no action for the present looking toward the modification of the standard sections of that society. It is possible that the sections are all right, but it is a positive fact that there is something wrong with the rail. This association could do no better work than to make an exhaustive investigation into the cause of the trouble, fix the responsibility where it belongs (whether with the manufacturers, or the maintenance of way or mechanical departments of our roads), and recommend a remedy. There is another line of investigation which is being pressed upon us more strongly every day, and one in which the time has come for us to do some original work. It is the design of a road adapted to the high speeds and wheel concentrations of the near future, which will admit of the same margins of safety as we now use in the design of bridges to meet the same conditions.

The report of the secretary and treasurer showed the following results:

Balance, cash in hand, March, 1904		$4,906
Receipts during the year	$10,327	
Expenditures during the year	6,673	
Balance to credit		3,654
Balance, cash in hand, March, 1905		8,560
Bills payable		631
Bills receivable		5,084
Membership in March, 1904		437
Members admitted during the year	57	
Members withdrawn	10	
Members dropped for non-payment of dues	18	
Members deceased	3	
Members lost, total		31
Net increase		26
Membership in March, 1905		463

The following members of the association died during the year: R. Southgate, L. F. G. Bouscaren, J. C. Hartigan.

Abstracts of most of the committee reports were given in our last issue, and we give herewith a general report of the proceedings. The annual dinner was held at the Auditorium Hotel on March 22, and as an auxiliary to the convention there was the usual large display of machinery and appliances in the parlors of the hotel.

WOODEN BRIDGES AND TRESTLES.

This report was under consideration for some hours, but an unduly large proportion of the time was devoted to discussing the definitions of the various members and parts. The definitions still remain unsatisfactory in many respects, and this is evidently not a good way to improve them or to spend the time of the convention. The report included specifications for bridge timbers; the specifications for yellow-pine for railway construction, as submitted by a joint committee of the Southern Lumbermen's Association and the Hardwood Manufacturers' Association (Engineering News, Feb. 23); and specifications for workmanship for pile and frame trestles. There was also a general drawing of a design for ballasted floor trestles, but this was not adopted and the specifications for workmanship were withdrawn. The specifications for bridge timber were referred back to the committee for rearrangement. In regard to the ballasted floor design, the report recommended that this should be of treated timber throughout, but it was shown that if the floor was covered with waterproof paper, the floor planks and the stringers need not be treated, thus reducing the cost.

ROADWAY.

At the convention of 1904, the committee's report was read by title, and at the last convention therefore it again submitted a revised form of the "Specifications for the Formation of the Roadway," originally submitted and discussed in 1903. These specifications were discussed at considerable length, but comparatively few changes were made. In regard to classification of material there was some discussion as to loose rock handled by steam shovels, and the clause was amended. The proposed clauses providing for alternative practice in regard to haul were struck out and another clause substituted. The loose rock and haul clauses as adopted are as follows:

Loose rock shall comprise all detached masses of rock or stone of more than 1 cu. ft. and less than 1 cu. yd., and all rock which can be properly removed by pick and bar, and without blasting; although steam shovel may be used or blasting may be resorted to on favorable occasions in order to facilitate the work.

Unless otherwise specified, the contract prices per cu. yd. cover any haul found necessary, and there will be no allowance made for any so-termed "overhaul."

In the part relating to the work of revising or widening existing lines, the penalty clause imposing damage upon the contractor for delays to trains was struck out, as several members who have carried out such work had found it more satisfactory to arrange with the contractor for the proper and safe handling of trains. The general clause making the engineer the "arbitrator" with final decision as to the meaning and intent of the specifications was objected to by some members, and Mr. Kelley (M. & St. L. Ry.) stated that he had formerly used such a clause, but after a judge had ruled that "the court will not delegate to any individual the right of adjudication," he had adopted a clause reading as follows: "These specifications shall be considered a part of this contract, to which reference shall be made in the adjustment of differences." After some further discussion the term "arbitrator" was struck out, and the clause changed as follows, although this was still unsatisfactory to many:

The decision of the chief engineer shall be final as to the intent and meaning of these specifications.

With this one exception, all references to the engineer have been eliminated throughout the specifications. The committee's proposed 12 ft. width of roadway was changed to 14 ft., its width between tracks was changed from 14 ft. to 13 ft., and some speakers wanted 12 ft. or 12 ft. 6 ins. (as now actually used on many lines), but it was thought that nothing less than 13 ft. should be recommended. Finally, the excavation of rock cuts to 12 ins. below subgrade was changed to 6 ins. The committee's conclusions, as amended, are as follows:

1. There should be recognized three widths of roadbed, and these should be selected to suit the possible density of traffic to be handled in the future. These widths should be 14, 16 and 20 ft.

2. A distance of 13 ft. between center lines of main tracks is recommended.

3. Rock excavations should be taken out not less than 6 ins. below subgrade.

4. No wasting should be allowed closer than 10 ft. from slope stakes.

IRON AND STEEL STRUCTURES.

This committee presented complete specifications for the designing and building of steel railway bridges up to 400 ft. span. The requirements for material and workmanship were practically adopted in 1903, but with these were new requirements for bridge design. The latter were discussed in detail, but it was not long before the wearing effect of discussing them, clause by clause, became evident and many things were passed for the sake of getting through the work. Many objections were made to the proposed impact formula and unit strains, and eventually that part dealing with design was accepted as a progress report and referred back to the committee, but it is to be printed in the "Proceedings," with the discussion. This was the third committee report, and it was not disposed of until the morning of the last day of the convention.

SIGNALING AND INTERLOCKING.

Only the conclusions of this report were taken up for discussion, and these (as amended) are given below. There were some objections to No. 7, and it was also suggested that No. 9 ought to include some reference to electric operation of distant signals, as pipe connections for distances of 4,000 and 5,000 ft. (as now sometimes used) are objectionable, while wire connections are not permitted under the rule as adopted. No changes were made, however, but a resolution was adopted to the effect that a sweep of 90° for the signal arm is recommended as good practice. The definitions and specifications presented in the report were not considered, but the following conclusions were adopted, together with recommendations for general plans for lead-outs and semaphore arm castings:

INTERLOCKING.—1. That inasmuch as interlocking signal plants were introduced to make the passage of trains safe at speed over track layouts more or less complicated by crossovers, turnouts, and crossings, the object in arranging interlocking signals is primarily to indicate routes for trains, and, secondarily, as a necessary consequence, speeds for trains.

2. That high-speed movements be governed by high signals, and low-speed movements be governed by low signals.

3. That only two high-speed signals be displayed on one mast, the top arm to govern the unrestricted speed, and the lower arm to govern all other high speeds.

4. That all low-speed movements be governed by one-arm low signals of dwarf construction.

5. That a distant signal be provided for each high-speed route.

6. That "red" be the "color" stop indication, and that the "horizontal" position of the arm be the "position" stop indication for all home signals.

7. That a mark of distinction be made between automatic block signals, and all other home signals, whether interlocking, trainorder, or manually operated block signals.

8. That home block signals be provided at all interlocking plants used as block stations.

9. That all mechanically operated high-speed signals be pipe connected. (Low-speed signals may be wire connected.)

10. That one distant signal only shall be provided for a high-speed route, and when "clear" it shall mean that all high-speed home signals along that route through the interlocking plant, including the home block signal, are "clear."

11. That every movement within the limits of an interlocking plant shall be governed by an interlocked signal.

BLOCK SIGNALING.—1. The best location for the telegraph, and manual, block signal is on a mast alongside and to the right of the track on which are run the trains that it governs; but, in the case of more than two tracks, when it is impracticable to spread them apart for this purpose, then the best location is on a bracket post, or on a bridge over the tracks.

2. It is good practice to make use of the electric slot to send the block signal to normal position, "stop," as the train passes.

YARDS AND TERMINALS.

This committee presented a revised form of its conclusions, as presented at former meetings. These covered yards, terminals and piers, and were adopted with little discussion. The only change made was that the space between a running track and the body track of a yard should be "not less than 16 ft.," instead of 15 ft., as formerly. Some abstract of this report has already been given.

WATER SERVICE.

This report related to the principles and practice of softening water for locomotive boilers. In the discussion, Mr. Kennicott, of the Kennicott Water Softener Co., referred to the great variation in analyses of the same water by different chemists; he also suggested that giving the proportions

of incrusting solids in "pounds per 1,000 gallons" would be more easily understood than "gains per gallon." Prof. Allen pointed out that the effect of treated water in enabling larger train loads to be handled should be considered in connection with the economy due to treatment. Mr. Raymer stated that the Pittsburg & Lake Erie Ry. is treating about 50,000,000 gallons of water per month. Water containing about 6 lbs. of scale-forming solids per 1,000 gallons is treated so as to form no scale, and Allegheny river water containing a high degree of sulphuric acid is treated so as to cause no corrosion. Mr. McGill thought that the problem of water treatment is not yet solved, either mechanically or chemically. It it customary to speak of two chemicals as being the only ones to be used, but he expects that others will shortly be found available. Mr. Berry, Chief Engineer of the Union Pacific Ry., said that he was very well pleased with the results of water treatment, but was emphatic in stating that the ordinary pumpers must not be depended on for the proper operation of the plant; some more skilled and intelligent inspection is necessary. The conclusions of the committee were adopted, as follows:

METHODS.—1. All water used in locomotive boilers contains scale-forming matter in solution or suspension, that is the cause of much trouble and expense in operating and maintaining locomotives.

2. In locating water stations along a railway, an investigation should be made of all the available water supplies, and care should be taken to avoid the use of poor water, or to curtail its use as much as possible.

3. If hard water is used, the hardness should be removed before it is put into locomotive boilers.

4. Hard water can be softened by treating it with chemicals. The chemicals generally used are lime and soda ash.

5. The chemical method of softening water, commonly used to-day, has been known for many years.

6. The mechanical methods of modern water-softeners are new and differ widely.

7. Water, whose hardness is due to carbonates of lime and magnesia, can be softened by the use of lime alone, without adding any soluble salts to the softened water.

8. Water, whose hardness is due to sulphates of lime and magnesia, can be softened by the use of soda ash, but in this case soluble sulphate of soda will be added to the softened water.

9. A water-softening method best adapted to any condition can be determined only after a study of that condition.

COST.—1. The cost of installing a water-softening plant varies according to the capacity of the plant, its type, cost of material and labor in its locality, and other local conditions.

2. The cost of operating a water-softening plant varies according to the efficiency of the water-softening apparatus, and cost of lime and soda ash (and other chemicals available) in its locality.

3. The cost of chemicals required to soften water varies according to the quantity of hardening matter in the water, and also its composition.

4. If the hardening matter consists of carbonates of lime and magnesia, the cost of chemicals for softening the water will be very little, because common lime is the only chemical required.

5. If the hardening matter consists of sulphates of lime and magnesia, the cost will be higher, because it will be necessary to use soda ash, or some more expensive chemical.

6. The average cost for chemicals and labor on the A. T. & S. F. Ry. was 2.8 cts. per 1,000 gallons; on the C. & N. W. Ry. it was 1.8 cts.; on the Southern Pacific Ry. the average cost for chemicals only was 4.4 cts. per 1,000 gallons, and on the Union Pacific Ry. it was 1.3 cts.

7. The benefits derived from water-softening plants are: Fewer boiler failures due to leaking; longer life of flues and firebox seats; reduced cost of labor for repairing and washing boilers; increased locomotive mileage between shoppings; increased ton mileage per pound of coal consumed; decreased number of locomotives in service; shorter time required for locomotives to go over the road; better feeling among the men, due to fewer failures and shorter time on the road; less expense in cost of overtime and delayed time.

ECONOMY.—1. If a railway runs through a region where hard water is the cause of trouble and expense, it would undoubtedly benefit that road to install water-softening plants. The actual benefits obtained are evidence of this.

2. If a railway has increased the size of its locomotives and found that it has more boiler troubles due to hard water than it had with the smaller locomotives, it would be a benefit to install water-softening plants.

3. It may be a benefit to soften any water used in locomotive boilers that contains 7 or more grains per gallon of hardening matter, or even less than 7 grains, if the hardening matter consists largely of sulphate of lime.

4. It may not be of much benefit to soften a water that contains 50 grains per gallon of alkali salts before treatment, and also a considerable quantity of sulphate of lime, for, although the water can be softened so that it will not make scale, yet it will cause trouble from foaming.

RECORDS, REPORTS AND ACCOUNTS.

The committee's recommendations as to general methods and also as to forms for bridge inspection reports were adopted last year, and the committee has now recommended certain forms for time books, section foremen's reports, right-of-way maps, deeds and leases. These were adopted, after some changes had been made.

BUILDINGS.

This committee presented a standard form of contract, based upon that adopted by the American Institute of Architects and the National Association of Builders. In regard to stations, it recommended the use of one general waiting room, with baggage room and ticket office at one end, and women's room and both toilet rooms at the other end. The proportions for building of different sizes were as follows:

Size of building.	50 × 20 to 75 × 28 ft.	80 × 30 to 90 × 35 ft.	100 × 38 to 125 × 45 ft.
	%	%	%
General wait. room.....	50	55	64
Women's room	15	13	10
Toilet rooms (2)	10	9½	8
Baggage room	10	9½	8
Ticket and tel. office.....	15	13	10

The Association adopted the recommendation of the use of one general waiting room for a local passenger station, without reference to separate waiting rooms for colored people.

In regard to engine houses, the committee's recommendation of the circular form as against the rectangular form was strongly opposed, and was not accepted. These recommendations were given in our issue of March 23, and were adopted, but with the changes noted below:

1. In a circular house the locomotives should stand normally with the tender towards the turntable.

7. Roundhouse doors should be made of non-corrosive material.

9. The floor should be of permanent construction. It should be crowned between pits and that part adjacent to pits within jacking limits should be of wood.

11. If the building is heated by hot air, it should be by an indirect method.

MASONRY.

The committee recommended the adoption of the specifications for Portland and natural cements as adopted by the American Society of Testing Materials. This action was taken, the specifications superseding those adopted two years ago.

UNIFORM RULES.

As no members of the committee were present the report was simply read by title. It was very brief and consisted of several rules for employees in the maintenance-of-way department.

BALLASTING.

This report submitted specifications for stone ballast, and notes on gravel, cinder and burnt clay ballast, together with alternative designs of roadbed cross-sections. The specifications for stone ballast were adopted; the remainder of the report was accepted as a report of progress:

STONE BALLAST.—1. Quality. Stone shall be durable enough to resist the disintegrating influences of the climate where it is used. It shall be hard enough to prevent pulverizing under the treatment to which it is subjected. It shall break in angular pieces when crushed.

2. Size. The maximum size of ballast shall not exceed pieces which will pass through a screen having 2-in. holes. The minimum size shall not pass through a screen having ¾-in. holes.

TRACK.

This report presented a revision of former reports in regard to track inspection, tool equipment and maintenance of surface and gage. There was a brief discussion as to the measurement of the gage of track. The report recommended "the distance between the intersection of the plane of the tops of the rails and the planes of the running sides of the heads of the rails." This was changed by vote of the Association as follows, and the report was then disposed of by being accepted as information.

The gage is the distance between the heads of the rails measured at right angles thereto at a point ⅝-in. below the tops of the rails.

OTHER REPORTS.

The Committee on Ties had a long report, but this was read by title, owing to lack to time. The committees on (1) Rails, (2) Signs and Fences, (3) Economics of Railway Location, and (4) Classification of Track, made brief verbal statements as to progress.

OFFICERS.

The officers for the current year are as follows: President, H. G. Kelley, Chief Engineer of the Minneapolis & St. Louis Ry.; Vice-Presidents, James Dun and A. W. Johnston; Treasurer, W. S. Dawley; Secretary, L. C. Fritch; Assistant Secretary, E. H. Fritch.

ELECTRIC POWER TRANSMISSION IN THE MISSOURI LEAD MINING DISTRICT.

In the lead and zinc mining district of Missouri, the mines are as a rule owned and operated by private parties or small companies, each with its own small steam power plant. Such an arrangement is of course very uneconomical in fuel and operating expenses. These conditions have led to the establishment of a power company, which has built a water power and electric generating station with a transmission line to and through the mining district and connections to numerous mines. This company is known as the Spring River Power Co., of Lowell, Kan. The company is composed of Chicago men: Mr. Francis W. Farwell is President; Mr. Jamot Brown, Vice-President, and Mr. Samuel Brown, Jr., Secretary and Treasurer. The work was designed and built by the Arnold Co., of Chicago; Mr. B. J. Arnold, President; Mr. George A. Damon, Managing Engineer, and Mr. Wm. H. Rosecrans, Chief Civil Engineer. Work was commenced in May, 1904, and is now practically completed. The map in Fig. 1 shows the location of the power station and present transmission line, with four substations. It also shows projected transmission lines running north to serve an extensive coal mining district.

POWER PLANT.

The dam and power plant are at Lowell, Kan., on the Spring River, at the confluence of Shoal Creek, in Cherokee County. The total length of the main dam is 1,250 ft., and half a mile up the river is a spillway for the discharge of flood water, which re-enters the river about two miles below the main dam by way of a ravine. The main dam contains 45,000 cu. yds. of earth, 1,000 yds. of stone riprap, 10,000 cu. yds. of concrete, and 300,000 lbs. of structural steel. The dam has a height of 30 ft. above low water, and extends from 10 to 16 ft. below, the base being built into bedrock. The width of the base is 28 ft. The dam consists of two parts: (1) An earth embankment 800 ft. long, in the center of which there is a concrete core wall reaching to the top of the embankment; (2) A concrete structure, 450 ft. long. At the north end of this concrete portion of the dam are situated the regulating works, made up of five Taintor revolving gates, operated by a crab and chains mounted on a car, which runs on a track above the gates.

The design of this plant is a radical departure from common practice, as is shown by the longitudinal and cross-sections in Figs. 2 and 3. The power house is located in the center of the river and is a part of the concrete dam. The superstructure of the power house is built of concrete blocks. The two turbine rooms flank the power house on either side and are also built in and made a part of the dam. These structures, with the regulating works, cross the stream at right angles. The water enters the wheels direct from the river proper, and after passing through them enters the river directly. Thus the river becomes the head race and also the tail race, and besides saving the expense of constructing races, it has been possible by this method of construction to use direct-connected machinery throughout. It also gives very still water over the intakes. By the use of the regulating works, no water need go to waste under ordinary circumstances, but an

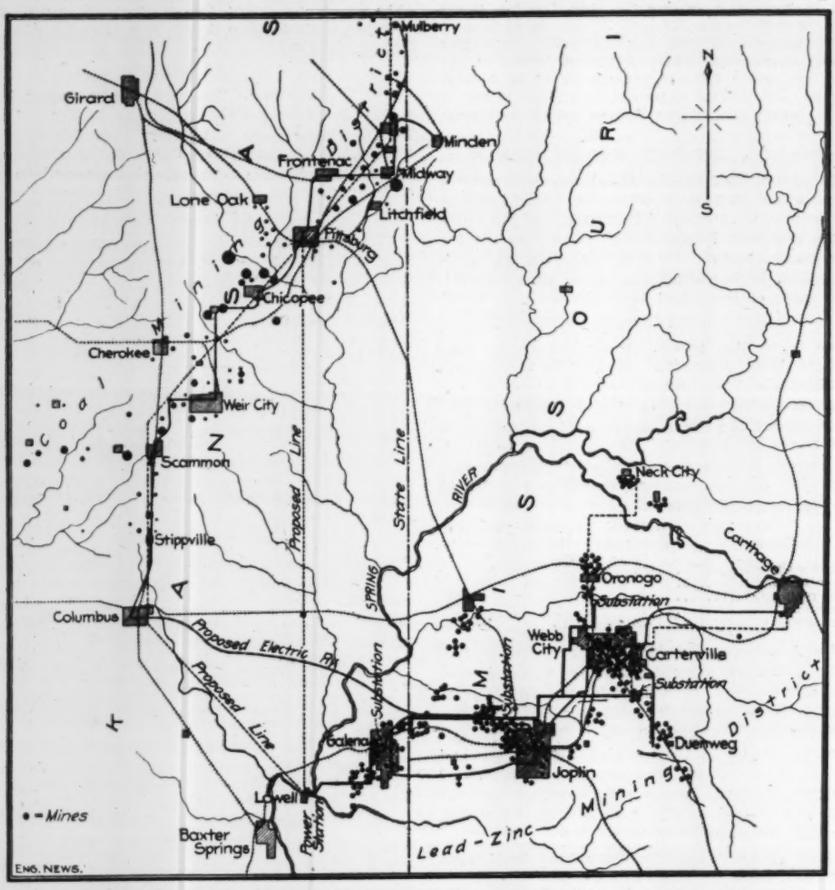


FIG. 1. MAP OF ELECTRIC POWER TRANSMISSION SYSTEM OF THE SPRING RIVER POWER CO. IN KANSAS AND MISSOURI.

The Arnold Co., Chicago, Engineers.

immense amount can be discharged in a very short time, should the circumstances require it. The turbine rooms are provided with slide gates for use in shutting water out of these rooms in case of repairs. The normal output of this plant is 4,000 HP., but 5,000 HP. can be furnished if required. Fig. 4 is a view of the downstream side of the concrete dam, with the 15-ft. discharge openings, while at the left are the regulating gates.

located between the two turbine rooms and contains two General Electric 1,500-KW. alternating-current generators directly connected to the two water-wheel line shafts. The machines are of the revolving field type, 25 cycles, 2,300 volts, and run at 185 revolutions per minute. There are also two exciters, two Lombard governors, two small pumps

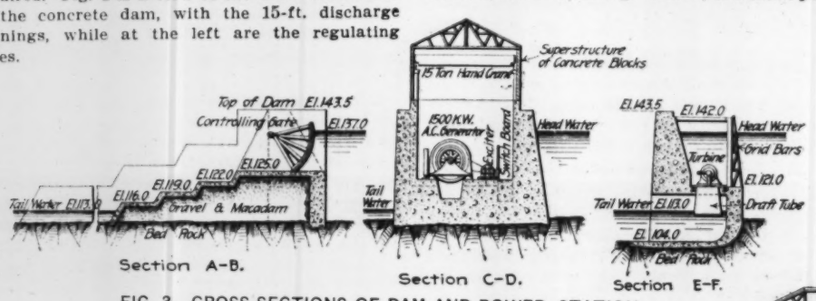


FIG. 3. CROSS-SECTIONS OF DAM AND POWER STATION.

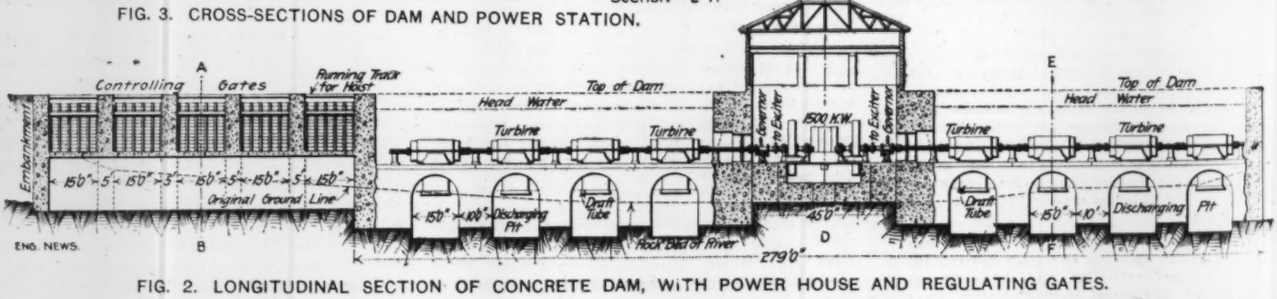


FIG. 2. LONGITUDINAL SECTION OF CONCRETE DAM, WITH POWER HOUSE AND REGULATING GATES.

There are two separate turbine rooms, each containing eight 42½-in. horizontal direct-connected Leffel water wheels set in open flume. The average head of water is 24 ft., and the water is discharged beneath the dam through the draft tubes into arched wheel pits. The generator room is and a switchboard. This building is equipped with a 15-ton crane. The exciter outfit consists of two 60-KW., 125-volt. belted generators, each having sufficient capacity to excite both generator fields. These exciters also supply current for lighting and power for operating circulating

pumps and the remote-control switching apparatus. The switchboard consists of five panels: two generator panels, two exciter panels and one panel for the auxiliary switches controlling the main high-tension switches in the transformer house. The power room is provided with electrically-driven pumps for circulating water through the transformer coils and for removing seepage water. The lead-covered cables leading from the generators to the transformers are run in tile ducts imbedded in the concrete of the dam.

The transformer house is separate from the dam and is built of hollow vitrified building blocks. It is 30 × 40 ft., with a tower 31 ft. high, and has the floor, door and window lintels and cornice of concrete. The lower floor of the transformer house contains six 500-KW. step-up transformers of the oil-insulated, water-cooled type, increasing the voltage from 2,300 to 33,000 volts for transmission. On the first floor are the bus-bar compartments, and in the tower are situated the oil switches and lightning arresters. It has a very complete system of high-tension, remote-control switches.

The concrete in this plant is made entirely from "chats," or the tailings of finely-crushed stone brought from the zinc-lead mines in the vicinity. This material was found to contain enough sand and fine material so that no other stone or sand was required to be used with it. The stone of the "chats" consists of limestone and flint ¾-in. in size and less. Excellent results were obtained, and the structure is said to be absolutely water-tight, testifying to the merits of this material, the use of which lessened the cost of construction. The concrete was composed of 1 part of Portland cement to 5 or 7 parts of "chats," as required.

TRANSMISSION LINE.

From the plant at Lowell, Kan., the transmission line extends 28 miles, touching Galena, Kan., and Cave Springs, Chitwood, Joplin, Webb City, Carterville, Dunwegg and Oconogo, in Missouri. The current is transmitted from the transformer station to the various substations over a line consisting of three No. 4 hard-drawn copper wires arranged in the form of an equilateral triangle with 44-in. sides. Porcelain insulators with iron pins are used throughout. The lines are spiraled every mile to counteract inductive effects, and the entire line is paralleled with a complete telephone system, so that patrolmen can call from any point. The high tension line has 35-ft. cypress poles with 8-in. tops, spaced 120 ft. apart and set 6 ft. into the ground. This is shown in Fig. 5, while Fig. 6 shows the transportation of the power and telephone wires. The secondary lines are run on 30-ft. poles, and the wire is all stranded copper, ranging in size from No. 2 to No. 0000. The poles for the secondary transmission lines have two cross-arms. The upper one is 4 ft. 6 ins. long, with four insulators spaced 18, 20 and 18 ins.; the lower arm (19¼ ins. below) is 4 ft. 2 ins. long, with two insulators 3 ft. 4 ins. apart. Each arm is braced in the same way as those on the poles for the primary transmission lines, Fig. 5.

The substations are built of pressed brick, and are 19 ft. square and 34 ft. high. Each substation is equipped with three oil-insulated trans-

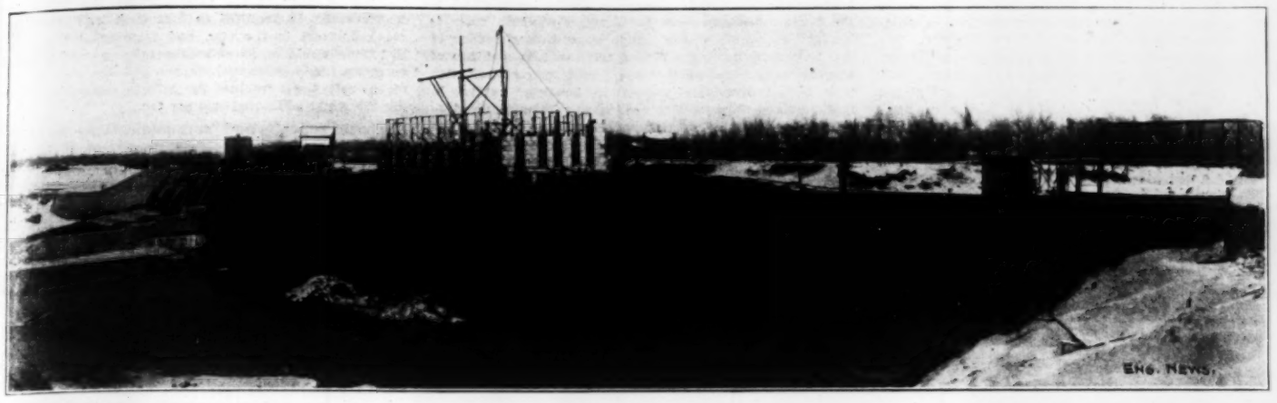


FIG. 4. DOWNSTREAM FACE OF DAM, SHOWING 15-FT. DISCHARGE OPENINGS, AND REGULATING GATES AT THE LEFT.

switches are provided at each substation, which permit the disconnecting of the substation alone or the breaking of the main transmission line at that point. The substations have been located as centrally as possible, and most of the important mines in the district can be reached by a run not exceeding two miles in length. The voltage is stepped down at the substations from 33,000 to 2,300 volts, and is delivered to the customers at this pressure. Line voltage is used on all motors over 50 HP.; the smaller motors are wound for 220 or 440 volts.

SPECIFICATIONS FOR STEEL RAILS WITH ESPECIAL REFERENCE TO WEARING QUALITY AND FREEDOM FROM BREAKAGES.

At the annual meeting of the American Railway Engineering & Maintenance of Way Association, held in Chicago March 21 to 23, one evening session was devoted entirely to the subject of rails. The Committee on Rails had only a brief progress report, as its specifications (adopted at the meeting of 1904) were not printed until late in the year, and it is not yet known whether any rails have been rolled according to these specifications, or what results have been obtained. There has been an impression that the committee advocated the use of steel high in phosphorus, but this is not correct. To the committee's report was appended the progress report of the special committee on rail sections of the American Society of Civil Engineers, which was presented at the annual meeting of that Society in January. It will be remembered that this special committee was appointed owing to statements that the heavier rails of the Am. Soc. C. E. section were not giving satisfactory results as to wear. After the reading of these reports communications were read from Mr. Thomas H. Johnson (Consulting Engineer, Pennsylvania Lines), and Mr. F. L. Moister (Philadelphia, Pa.). Abstracts of these reports and communications are given below:

COMMITTEE REPORT: AM. RY., ENG. & M. OF WAY ASSOCIATION.—It has been the aim of the committee, by the introduction of clauses to regulate the finishing temperature, to get good safe rails from the ordinary rail steel which is high in phosphorus. But we all appreciate that a better rail can be obtained from steel lower in phosphorus, in that it is less liable to be brittle. This would increase the cost, and we have therefore left this matter of phosphorus limit to be adjusted by the individual railway companies with the mills.

On account of the large tonnage of low phosphorus, basic open-hearth steel rails now being rolled, the members of the committee are requested to get all the information possible bearing on the specifications, and tests of such rails and their behavior in service. It would also be desirable to get all possible data on rails rolled under our specifications (tonnage, tests and behavior in service); for comparison, we should have similar data on rails rolled to other specifications, especially where failures have occurred.

COMMITTEE REPORT: AM. SOC. C. E.—Your committee has given consideration to the work of committees on rail specifications which have been appointed by the American Railway Engineering & Maintenance of Way Association, the American Society for Testing Materials, and the Engineering Standards Committe (Great Britain), and has also obtained and discussed data pertaining to the service of rails made by different metallurgical processes, and under various specifications. In addition to this they are keeping record of the use of rails of the American Society's section.

While the wear of the heavier-sectioned rails is not as satisfactory as that of the lighter ones, at the same time there is not a demand on the part of the railways for a change in any of the American Society's sections, and the manufacturers are entirely satisfied with these sections. In view of the above, your committee does not now recommend any change in the American Society's sections.

THOMAS H. JOHNSON.—I can only reiterate the results of investigations of others, which may be briefly summarized as follows:

1. Resistance to wear is a function of fineness of grain.
2. Fineness of grain is a result of mechanical treatment at proper temperature and is wholly independent of the chemical composition.
3. The manufacturers have developed the present mill practice along the line of increasing the tonnage output

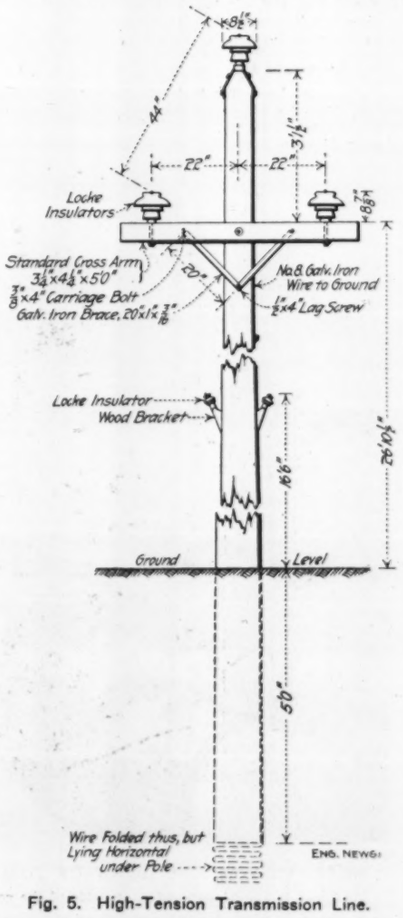


Fig. 5. High-Tension Transmission Line.

regardless of other considerations. One feature of the modern practice is the high speed of the rolling train, by which the time for rolling has been reduced to two minutes or less, where it should be 8 to 10 minutes, in order to allow the rail to gradually cool to a proper finishing temperature. Holding the rails before the finishing pass is a distinct gain, but not enough. We are confronted by a commercial condition. To go back to the slower speeds of the earlier practice would mean a greatly reduced output, which the manufacturers will not consider. To obtain the desired result with the present speed of rolls will require a longer distance between the stands of rolls, which is physically impracticable at most of the mills.

4. The initial temperature at most of the rail mills is made too high. (See Risdale's paper on "The Correct Treatment of Steel," before the Iron and Steel Institute, September, 1901, in which he shows that work done at temperatures above about 1,000° C. (950° to 1,050°) has no effect in changing the size of the grain from the normal crystallization of the ingot.)

As illustrating the second point stated above, I would refer your committee to the analyses of a number of rails made by John Brown & Co., of England, reported by Capt. R. W. Hunt in the "Journal" of the Franklin Institute for May, 1889. I can supplement Capt. Hunt's list with two additional cases, both Cammel Sheffield steel—one in service on the Southern Ry., from 1867 to 1901, the other on the P. C. C. & St. L. Ry., from 1868 to 1902. The analyses are as follows:

	Southern.	P. C. C. & St. L.	
Carbon	0.158	0.273	0.22
Manganese	0.77	0.28	0.21
Phosphorus	0.114	0.050	0.05
Sulphur	0.067	0.040	0.031
Silicon	0.490	0.025	0.035

I give two analyses of the P. C. C. & St. L. rails, made by different chemists from different samples cut from the same rail. The Southern rail, with the exception of silicon, is ordinary structural steel; yet as a rail steel it has had a life in service of a third of a century. These analyses, taken together, so strongly emphasize the fact that when the heat and mechanical treatment are correct, the chemistry is of no avail, that further comment is unnecessary.

The micrographs of the two rails cited above show the characteristic structure of low carbon steel, and in both cases the texture of grain at the center and edge of the head is scarcely distinguishable as to fineness of grain. This is the point to which our rail makers must come, if we are to have rails with satisfactory resistance to wear.

I trust that your committee, and through them the association, may realize the supreme importance of this feature. Holding the rail before the final pass makes the grain at the center of the head smaller than when not so held, but the gain is not enough. The standard toward which we should strive, and which we should seek ultimately to obtain, is a rail in which the micrograph will show a grain at the center of the head approximately as fine as near the edge. I would like to see this requirement made the governing feature of our specifications.

To attain this end it will be necessary that the manufacturers recognize the physical necessities of the railways and be willing to meet them, and that the railway engineers realize the commercial situation confronting the manufacturer with a willingness to pay a fair compensation for increased cost. If they can come together in this spirit of mutual recognition the methods of obtaining the desired end will be soon worked out. That end accomplished we can eliminate from our specifications all the chemistry (except perhaps as to phosphorus) and leave the manufacturer free in that respect.

F. L. MOISTER.—Considerable progress has been made the past ten years in the heat treatment of steel rails. Probably the most important factor has been the introduction in recent specifications of what is known as the "shrinkage clause." The object of this clause is to specify a shrinkage which will insure the rails being rolled and finished at the proper low temperatures, and thus produce the fine structure which we believe means good, tough, well-wearing rails.

Despite the improved methods of rolling and finishing, there are still an alarmingly large number of rails which break in the track, which cannot be attributed alone to heavier service. An examination is made and the verdict is generally—"improper heat treatment." The idea is fostered that some one in the mill has blundered and the

rail, or rails, in question have been finished too hot in rolling, thus producing the enlarged grain due to uninterrupted cooling from a high finishing temperature.

It is generally accepted that the rails as now rolled are giving good wear in tangents, barring breakages, and that only those rails in curves or grades are not giving the desired wear. This latter condition is due to, first, extra heavy or severe work, and, second, cutting or grinding action of the flange of the wheels, caused by very imperfect side bearings under heavy cars.

It has been noted in numerous cases that individual rails from the same heat of steel show greater variation

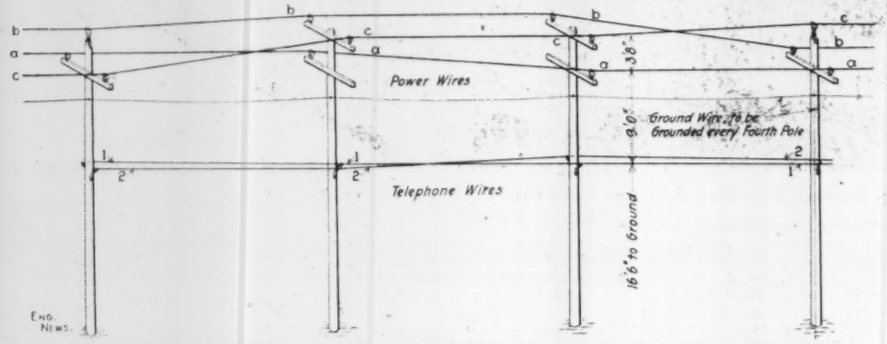


FIG. 6. TRANSPOSITION OF POWER AND TELEPHONE WIRES ON THE TRANSMISSION LINE.

in their physical properties than rails from different heats, and it is one of the reasons advanced for specifying a drop test from one heat in five, instead of one from each heat. An examination into practice at the rail mills convinces one of the approximate uniformity of the methods of heating and rolling; in fact, there is not enough difference in the heating and rolling and finishing temperature in rails from the same heat of steel, nor in the chemical analysis of the rails, to account for such variations.

For instance, the writer was testing and inspecting rails rolled at a mill where the direct process of rolling is in use. A drop test was made on each heat of steel and occasionally a rail would break under the drop. Two pieces were cut from other rails of the same heat (such retests had in all cases the heat number stamped on them, so there was no possible chance of other heats being substituted) and in a great majority of cases these retests stood the drop test. Drillings were taken from the broken rail and tensile test piece cut from it. There was nothing in the analysis to account for the failure and the tensile test did not develop any unusual conditions. This latter is not to be wondered at, as it is generally known that steel which will not resist shock will sometimes give good results under the slow pulling of the testing machine. Microphotographs of the broken rail showed it to be brittle or the grain larger than is desired, but did not account for the fact of its being brittle.

Having uniform steel chemically, uniform methods of heating and rolling and uniform shrinkage, the resultant rails should be uniform in physical properties. That they are not uniform is positive evidence that at some critical stage of the process of manufacture there is lack of uniformity. Starting at the first stage in the manufacture of steel rails, by process of elimination we get rid of the iron from the blast furnace, the metal used in the converter, the conversion of the steel, the recarburization, the pouring of the steel into the molds, as all of these processes are under excellent control, and arrive at the crux of the whole situation, that is, the solidification of the steel in the ingots. It is the writer's contention that at this point is produced all or most of the difference in the physical properties of rails from same heats of steel.

In present practice the steel is poured into the mold and as soon as enough of the outer surface of the ingot within the mold is solidified, to prevent bled ingots, it is stripped. The steel is now in two conditions in the ingot, the outer portion solid and the inner portion still liquid. In this condition, without allowing for any further cooling, the ingot is taken to the soaking pit and allowed to stand in it subject to a certain amount of heat for such length of time as in the opinion of the various mills will equalize the heat and insure the center being solid. That ingots are stripped when the center is still liquid is proven by the fact that the hydraulic plunger of the stripping machine sometimes breaks through the thin crust of solid metal on the top of the ingot and liquid steel is forced out over the top of the ingot mold. There is no question but that a large percentage of ingots so treated do properly solidify and the heat is equalized. But there is likewise no question that occasionally an ingot is drawn from the pits and rolled when the center is almost liquid, not perfectly solid and with little or no cohesion between the atoms or molecules comprising the mass.

Soaking pits are not intended to act as a medium for heating ingots, but as an intermediate station in the process of manufacture, where the steel solidifies and the heat equalizes. That is, the center of the ingot, which is the hottest portion, cools down and the whole mass is brought to such uniform temperature throughout as is best suited for rolling. The writer has seen etchings of a great many rails which have broken in the track, and they almost invariably present an irregular surface in that small cavities appear, which one investigator pronounces to be filled with foreign matter. There are no other indications of a piped ingot and these cavities may be produced by rolling steel while the center is not thoroughly solid. It is self-evident that steel injured in this manner is permanently injured, and no subsequent heat treatment, other than remelting, can restore it to its proper condition. Another feature of charging ingots while their central portion is liquid is that the heat of the pit undoubtedly delays cooling and the center remains liquid longer than it otherwise would and segregation is proportionately increased.

In the specifications proposed by the committee on rail of the American Railway Engineering and Maintenance of Way Association, and adopted by the association at the convention last March, is the following clause:

Ingots should be kept in a vertical position in the pit heating furnaces until ready to be rolled or until the metal in the interior has time to solidify.

This seems to the writer to be a step in the wrong direction. Had the association specified that after stripping, the ingots should not be charged into the soaking pits until such time had elapsed as would insure the metal in the interior being solid, the rails rolled under these specifications, which in all other respects represent the most advanced and best methods of rolling mill practice, would have been of better quality and wear longer and more uniformly in the track.

To change the practice at any of the mills so as to allow the ingots to become solid before charging in the pits would entail some additional cost in the increased heating capacity, made necessary by the lar[ge] which would be required to heat such ingot th[e] charged direct in the pits, and increased cost [of] But there would be fewer broken rails to replace [the] correspondingly decreased danger and the incre[ase] of the rail would warrant the railway companies [in] ing the slight additional cost per ton.

These reports and communications we[re] lowed by a general discussion, and it [is] noted here that Mr. Hunter McDonald [in] presidential address stated that there [was] doubt that the heavier rail sections gave [un]satisfactory results; he suggested that it wo[uld] appropriate for the Association to investiga[te] ascertain definitely what is the trouble an[d] it can be remedied. The statements made [in] discussion supplemented those made a year [in] regard to the growing troubles with def[ective] steel in heavy rails, and it appeared to b[e the] general opinion that these troubles can be [and] should be remedied by the manufacturers. The specifications as adopted by the Associatio[n in] 1904 provide that "the test piece shall, preferably, be taken from the top of the ingot." At this meeting it was decided to strike out the word "preferably," making it compulsory to take the test piece from the top of the ingot. This question of the durability and reliability of heavy rails is one of great importance, and we give herewith some abstract of the discussion:

MR. W. R. WEBSTER.—Nobody is uniformly getting a drop test made on a rail from the top of the ingot, and a representative of one of our leading roads claims that one of the mills which is now meeting the requirements of the specifications could not do so if the tests were made on rails from the tops of the ingots. When we took up this matter three years ago some of the manufacturers seemed to think it would be impossible to identify the rail from the top of the ingot. I consider it to be a decided gain, which is the outcome of several discussions which we have had with them in the past year, for them to say now that they can identify this rail and are willing to give it to us.

MR. KENNEY (Pennsylvania R. R.).—In almost every rail mill to-day the drop test is made on a rail made from the bottom of the ingot, and excuses are made that it is impossible to take it from the top; the truth is they do not want to take it from the top because the rail is more liable to be segregated and will not stand the test I am sure that in the case of one mill from which we get rails, the rails taken from the top of the ingot would not stand the test. It is not the best rails that are rolled which trouble us, but the worst ones; and it is the worst rails that should be tested, not the best ones. Those from the top of the ingots are the worst, because great segregation is found almost invariably in the top of the ingot.

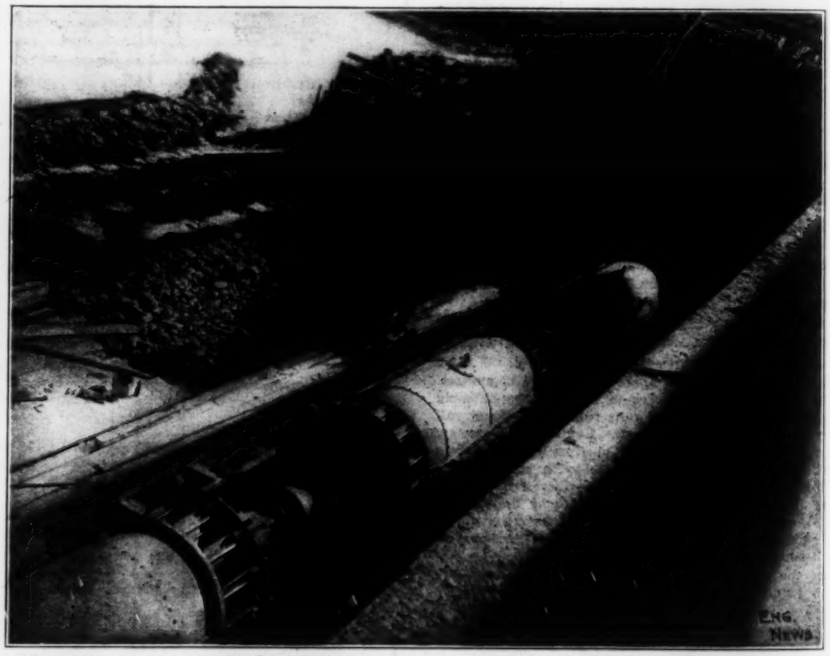


FIG. 7. VIEW OF ONE GROUP OF TURBINES OF THE SPRING RIVER POWER PLANT.

(The wall in the background is one side of the generator room, through which the wheel shaft passes.)

MR. E. E. ABBOTT (Illinois Steel Co.).—It is easy to understand why a discard is made from the top of the ingot. From the weight of the steel the metal at the base of the ingot is under greater pressure in cooling. In addition there is the effect of escaping gas which would go to the top. This partly accounts for the fact of the steel at the top not being as solid as that at the bottom.

MR. W. C. CUSHING (Pennsylvania Lines).—I think it will be a great advantage to have the test rail taken from the top of the ingot. During the past winter there have been a great many breakages of poor rails, and the trouble we have had has been almost entirely from piped rails. An official of one of the prominent rail companies was asked if it was possible to absolutely eliminate piped rails as a matter of safety from a traffic standpoint. He replied that it is entirely possible, but that the only way is by cutting off a large percentage from the ingot. If we can smash these piped rails before we put them in the track we have made that much progress; but what we really have to face is the fact that there must be more sheared off from the top of the ingot before we shall be able to eliminate piped rails. One of the steel mills has adopted that precaution with reference to its 100-lb. rails, because of the fact that the sheared-off portion can be rolled into rails of smaller weight (industrial rails of 20, 30 or 40 lbs. to the yard). But the sheared-off portion from the 100-lb. product is ample to take care of the small section rails, consequently, when it comes to shearing off other rails in the same way, say, 85-lb. rails, for instance, which make up a very large percentage of the rails used in the country, there is no market left for rolling the waste product into the smaller sections, and the result is that there is a waste to the mill.

MR. MONTFORT (Louisville & Nashville Ry.).—R. W. Hunt & Co. have been using the drop test for about 15 years on our rails, and under our specifications for an 80-lb. rail we have a drop of 24 ft., and I do not recall having seen a single rail which failed under that drop. We also had the Carnegie Steel Co. roll 80-lb. rails under the same specification without any breakage. They furnished us in '98, '99 and 1900 with Bessemer steel rails, under these same specifications, drop test of 24 ft. for an 80-lb. rail, with few breakages.

MR. WEBSTER.—We are now coming to a metal that is not as good as what we tested before. We have been coming to the spongy metal, or piped metal, or metal liable to fail in the track. In some of our discussions it has been stated that the mills put an identification mark on the top rail from each ingot, so that if there is a breakage the railroad company would know whether it is a top rail or not, and be able to follow it up. There is one other point that we care to get an expression of opinion on, that is in the fourth clause in regard to the finishing temperature and the shrinkage clause. We call attention to the fact that the shrinkage clause we have used is the shrinkage clause used by the Pennsylvania R. R. and the Pennsylvania Lines. The temperature used is the temperature in the R. W. Hunt & Co. specifications. There is nothing new in either the shrinkage or temperature, although we have put the two in. When they speak of the shrinkage clause and discuss it, they are discussing what is in use by the Pennsylvania R. R. The Pennsylvania R. R. controls the output of two of the steel works, and they are having that specification complied with, and we would like to know from the manufacturers why they cannot comply with the shrinkage clause as given in our specifications. Then we would like to know from the railroad engineers what their views are in regard to the same. We have been asked to try and get a better rail, a rail which will be a safer rail, and we feel that the heat treatment is one of the most important matters in securing a good rail, and whereas the shrinkage clause only covers the final pass, it is the work on the previous passes which is important—the work below a given temperature of steel will change the structure, and below that will only change the form without changing the structure.

I think that the Maryland Steel Co. is complying with the requirements of their specification in this respect for the Pennsylvania R. R. If they can do it other mills can do it too. Let us ignore the wearing properties. Let us take the brittleness. High finishing temperature gives large grain, and that gives brittle rails. You say the rails are satisfactory. I would like to hear from some of the railroad companies. If they are getting satisfactory 80-lb. or 90-lb. rails, or over, made at any mills, then the committee has misunderstood the whole subject. If the rails are satisfactory, there is no use of the shrinkage clause. If the rails are not satisfactory, we are trying to get you a better rail. We are trying to find out if you are getting a satisfactory heavy rail.

MR. W. C. CUSHING (Pennsylvania Lines).—Since 1899 every year has brought a worse rail than the previous one, without any question; all that is necessary is to look at the reports that come in. It has got to be a very serious question and the trouble we have had has been largely from piped rails. There is no doubt at all that there has been a decided decrease in the quality of rails since 1899, and from that year you can pick them out; there seems to have been a sudden change in practice in more than one mill which has produced a rail that has been gradually getting worse.

MR. C. S. CHURCHILL (Norfolk & Western R. R.).—Our experience with rails has been from four mills, and from the four mills we have got the same shrinkage temperature, according to our inspector. The shrinkage is 6 ins. I had very careful reports made, and in each case the statement was made that the results obtained at all four mills were practically the same as far as shrinkage was concerned, and in other respects they were very similar. Nevertheless, in the last two years we have had a great many failures of rails and investigation has shown them to be mostly piped rails. I took it up personally with the mills, visited the works, and from my observation and other statements which have been made, it would appear that the present practice of rolling rails was all toward getting them out rapidly. Everything was paid for by the ton; all the labor was gaged by the ton, and there was the greatest incentive possible to get the rails out. In doing that, they sometimes overlooked the cropping off of the ingot to such an extent as perhaps should be done. It has since been acknowledged that it was possible to crop them still more than they had done.

The statement has been made at these meetings, within two years, by the manufacturers, that it was impossible to get rid of bad rails. I think the manufacturers know how to do it. I think we people who use the rails ought to be eased up a little on our troubles, and not have so much of this feeling of fear of broken rails on the road. We pay the money we are asked to pay for the rails. We pay more money than the rails are sold for abroad by these mills, and under these circumstances I think it is time for the mill men to unite with us to get the result. Evidently something is hidden, because the statements are made plainly that it is possible to get these results. As to the condition at the top of the ingot, we know what that is; there is a large amount of spongy material which must be got rid of, and the only question is how to get rid of it. The time is coming for the mills to use the cropped ends for other things than railroad rails.

MR. H. R. SAFFORD (Illinois Central R. R.).—Our experience in the last five years with 85-lb. rail, which is the section we have used almost entirely, is in the direction outlined. We did not have a great deal of trouble with broken rails until the last winter—rails laid two or three years ago. Our trouble has been largely from piped rails and from soft rails in which the wear is evidenced on the curves. Our broken rails, however, in the last year have been largely on straight track, and the track conditions were much superior, the line having been ballasted in that time and the wheel load little increased, which shows that we get a more brittle rail. We have looked into the chemistry part of the proposition pretty thoroughly, and do not feel that the trouble is in the chemistry. Our specifications run close to the specifications of the Maintenance of Way Association. We have felt that the trouble was largely mechanical, and the question which interested us probably more than anything else is the proportion of the ingot which should be removed. In conversation with an old steel man I was told that 25 or 30 years ago, when we got 60-lb. rails which would give 25 years' service, a large proportion of the ingot was removed and is removed at the present time.

MR. HUNTER McDONALD (Nashville, Chattanooga & St. Louis Ry.).—We were called on some time ago to look up the question of a large number of broken rails, and I made the inspection myself three or four different times. I found that there was a mark on the brand side of every rail rolled that did not appear on the opposite side, and that a large number of breakages were along this mark. We took that up with the manufacturers and found it was due to a badly shaped roll in the roughing, which they afterward corrected. The rails began to show signs of breaking in other ways. The breaks would run from the head to the web in a diagonal line about 2 ft. in length, and upon investigation at the mill it was discovered that one rail in the pass had been allowed to stop under the hot saws for an unusual length of time, due to some trouble with the mill, and it seems that the water used to cool the journals of the hot saw was allowed to drip on the ends of the rail, cooling the ends, while the middle remained hot. One of the rails split from one end to the other on the bed, and in that way called the attention of the mill men to the fact that the rails were being cooled on the ends too quickly. A large number of breaks were traced to this cause, which the mill has since remedied, and the breaks have become much less. Some of the rails turned out showed signs of piping, and in every pipe was found a small amount of what looked to be slag. That was accounted for by the mill men by the fact that in pouring the ingot, pieces of the fire brick at the top dropped into the ingot and found their way into the rail. They say that they remedied that by using a different kind of lining at the top of the ladle.

THE EFFICIENCY OF BELT CONVEYORS is briefly discussed in the last Annual Report of the Government Mining Engineer, Transvaal Mines Department, from which we quote as follows:

For surface transportation the belt conveyor is becoming widely used. During the past year the continuous mechanical haulages have increased 25 in number and 406 HP. These are nearly all conveying belts. The chief reason for their popularity is the saving of manual labor and attendance effected, but, in addition to this, the usual work required, viz., a horizontal transmission of from 200 to 500 ft. and a lift of from 20 to 50 ft., is performed more economically than with the methods previously in vogue—gravity tramway and elevator, or rope haulage up incline.

At the Van Ryn Gold Mine Estate the belts are driven by electric motors, so that the power consumed is readily measured. The following results were obtained:

One conveyor carried 142,800 lbs. of rock per hour 199 ft. horizontally and raised it 48.5 ft.; power, 8.11 HP.; efficiency, estimated on the vertical lift only and including motor losses, 43.12%; power required to drive the empty belt, 3.69 HP.

Another conveyor carried 177,856 lbs. of rock per hour 497.5 ft. horizontally and raised it 25.5 ft.; power, 8.47 HP.; efficiency, estimated as in the previous instance, 27.04%; power required to drive the empty belt, 2.94 HP. In this instance is also included the power required to drive the traveling tripper and to actuate the continuous weighter, an amount difficult to determine exactly, but which is probably responsible for the drop of efficiency below 40%.

A NEW AND IMPORTANT LAW AFFECTING SUB-CONTRACTORS AND SELLERS OF MATERIAL TO PARTIES HOLDING GOVERNMENT CONTRACTS.

By W. M. S.

President Roosevelt, on Feb. 24 last, signed an Act of Congress of interest to sub-contractors and material men who furnish labor or material to a general contractor with the United States Government for public works, and to surety companies or individuals who go on the bond of such contractors.

The provisions of the Act of Congress, approved August 13, 1894 (28 Statutes at Large, page 278), which was the law on the subject prior to the signing of the Act above mentioned, require all persons entering into a formal contract with the United States for the construction of any public building or the prosecution of any public work or for repairs upon any public building or public work, before commencing such work, to execute the usual penal bond with good and sufficient sureties, with the additional obligations that such contractor or contractors shall promptly make payments to all persons supplying him or them labor and materials in the prosecution of the work provided for in such contract.

In analyzing this portion of the Statute it can be said that the word "person" includes both natural and artificial persons; that is to say, individuals, partnerships, corporations, and all kinds of companies or associations. The words "public works" are very broad in their meaning and take in all manner of public improvements, such as roadways, sewers, electric plants, fortifications, dredging, grading, etc., etc. But the furnishing of mere supplies or material not used in the prosecution of such "work" would not fall within the provisions of the law. The "usual penal bond" is the ordinary bond conditioned upon the performance of the contract by the contractor which was in use prior to the passage of the Act. This bound the contractors and the sureties to pay to the United States a certain sum of money, but provided that the bond should be void and of no effect if the contractor performed the contract. If he failed to perform, the bond became an unconditional one, or, practically, a promissory note payable on demand. "Good and sufficient sureties" are such as are satisfactory to the officer of the Government whose duty it is to pass upon the regularity and sufficiency of the bonds, usually the officer who signs the contract on behalf of the United States. No mention is made in the Statute of the amount of the bonds, and it is accordingly left to the discretion of the Government officer to require bonds of such amount as he may deem sufficient; and if he at any time after the execution of the contract and bond concludes that the bond is insufficient, or not good, he may require an additional bond. The words, "all persons supplying him or them labor and materials in the prosecution of the work provided for in such contract" refer only to those who furnish labor or material to the person who has a contract with the Government, and only to labor and material actually furnished and used in the prosecution of the work covered by the contract between the Government and such persons. Material men, labor contractors, and workmen, who furnish material or labor to sub-contractors do not come within the provisions of the Statute.

The Statute of 1894 further provided that any person or persons making application and fur-

nishing an affidavit to the Department under the direction of which the work is being or has been prosecuted that labor or material has been supplied by him or them for the prosecution of such work and not paid for shall be furnished with a certified copy of the contract and bond.

This provision was intended to enable persons who have rights under the Statute to secure properly authenticated copies of the papers necessary to form a basis for a suit to enforce his or their rights as will be explained below, as well as to prevent persons having no rights from securing such papers for improper use. The "application" can be made by the sub-contractor or material men either in person or by attorney or agent, but the "affidavit" must be duly executed by the person or persons who furnish the labor or material. The application may be addressed either to the officer who signed the contract on behalf of the United States or to the Secretary of the Department under which the work is being or has been done. The affidavit need only state the points required by the law, but must not omit any of them or information necessary to identify the contract and work. The following form may be followed:

State of——— } to wit:
County of———}

I, A—— B——, being duly sworn, do depose and say: That I have furnished certain labor (or material or labor and material) to one C—— D—— for the prosecution of the work of constructing a Post Office building at Washington, D. C., under contract with the Treasury Department, and that I have not been paid for said labor (or material, or labor and material).

A—— B——

Subscribed and sworn to in my presence this——day of——190—.

E—— F——,
Notary Public.

Thereupon a certified copy of the contract and bond will be furnished, and under the final provision of the Statute suit may be brought in the name of the United States against the contractors and sureties and prosecuted to final judgment and execution, provided the United States are involved in no expense. At this point the sub-contractor or material men must necessarily secure the services of an attorney to bring suit if the contractor and sureties still refuse to pay, and should thereafter be guided by the attorney's advice.

Under this law, according to decisions of the Courts, the United States had no right to have any claim they might have against the contractor satisfied to the exclusion of the claims of sub-contractors and material men. If the penalty of the bond was insufficient to pay all claims, the United States had to share pro rata with all other claimants under the Statute, and a sub-contractor or material man might secure a copy of the contract and bond and institute his suit at any time after the conditions mentioned in the Statute first came into existence, so that it might happen that he would secure his judgment and possibly execution before the United States or other claimants knew they had or would have a claim.

The recent Statute, however, removes these dangers to the interests of the United States, while it does not impair, although it may postpone, the rights of other claimants.

Under the new law (Act of February 24, 1905) sub-contractors and material men may not institute suit until at least six months after the performance and final settlement of the contract between the Government and the general contractor, nor can such suit be instituted after one year from such time. But if the United States should institute a suit at any time on the bond, the sub-contractor or material man may intervene and be made a party to the suit and have their rights determined and secure judgment, but their rights are subject to the prior settlement of the judgment given to the United States, whatever it may be. If the remainder is not sufficient to pay all claimants it will be distributed pro rata among them. If the United States bring no suit, all creditors must join in one suit and the sureties may pay the amount of the bond into Court and be discharged from further liability. The suit may be instituted by one or more creditors, but a separate suit may not be instituted by others.

It will thus be seen that the law as it now stands contains more restrictions upon the right of sub-contractors and material men to recover the price or value of their labor or material furnished to Government contractors than were imposed by the previous law. It becomes more important, therefore, to them to know their rights. They cannot resort to attachment of material after it passes into the possession of the United States, as such action would interfere with the functions of the Government; they cannot attach money in the hands of United States officers belonging to the contractor nor ordinarily secure the suspension of any payment due to the contractor on account of the contract. They can, of course, sue the contractor and if they secure judgment, levy execution on his property outside the hands of the Government, if they can find any. They should, therefore, if they feel that they may have to resort to suit on the contractor's bond, exercise care to know that they are contracting with one who has a formal contract with the United States and that the bond is given by good and sufficient sureties, otherwise they may discover too late that they are left entirely without remedy for the wrong which has been done them.

THE CASE OF HENRY CORT.*

By Charles H. Morgan,† M. Am. Inst. Min. E.

I. CORT'S INVENTIONS.

Under this head, it is unnecessary here to enter into details. The facts have been repeatedly published,‡ and a brief outline of them will be sufficient for my present purpose.

Henry Cort, born in 1740 at Lancaster, England, became a navy broker in London about 1765, and gained from that business in about ten years something more than £20,000, which he devoted to perfecting the manufacture of iron, building a mill at Fontley, near Portsmouth, and prosecuting, between 1777 and 1783, the experiments which culminated in his two patents, one for puddling iron and the other for shaping it by rolling between grooved rolls. Careful study of the contemporary evidence, including Cort's specifications, the testimony (in act as well as word) of his business rivals, the public declarations of eminent authorities, and the history of the times, leaves no possible doubt that Cort was the real inventor of these two inestimable improvements.

In the case of Cort, Dr. Percy mentions one or two prior inventors,‖ discovered by his researches, who seem to have been working on the same lines, and to some extent with the same general ideas. But they do not seem to have put their ideas into practical use. The malicious and false testimony, denying the practical merit, and thus the patentable character of his inventions, will be chiefly alluded to later. It does not deserve serious consideration here. On the whole, it may fairly be said that beyond all honest doubt and by substantially universal acclaim, Henry Cort was the first to perfect, put into successful operation, give to the world by sufficient description, and teach to other operators, his licensees, the puddling of iron and the rolling of puddled iron between grooved rolls.

II. THE VALUE OF CORT'S INVENTIONS.

As I have already observed, Henry Cort accumulated a fortune of more than £20,000 as a navy broker, furnishing supplies for the British navy, at a period when England stood at bay, fighting for her colonial possessions in North America, and almost for her own national existence, and when the power and prowess of her navy was her chief, if not her only, reliance. Yet no forge or furnace in England could make iron fit for navy use. The nation, though endowed with vast deposits of iron ore and of coal, was dependent upon the purer raw materials of Sweden and Russia for wrought iron of good quality; and the Admiralty specifications called for Swedish or Russian iron. While Cort was in business as a navy broker, the demand for these foreign irons increased the price nearly 200%. What was even worse, the dependence of England upon this foreign supply might possibly, at any moment, become a source of fatal weakness in war.

No doubt it was the perception of this critical si[tua]tion which stimulated Henry Cort, both as a patriot and [as] an intelligent inventor, to risk his entire fortune and [to] peril upon the attempt to render his country independe[nt of] the world in a particular so essential to her prosperity [and] the result of his enterprise may fairly be said to [have] altered profoundly the history of the world. Before [Cort's] England paid annually to Sweden alone £1,500[,000] wrought iron. As the "London Times"* has said:

Then came the war, commercial embarrassme[nt,] preciated paper, foreign prohibitions, and an overp[ow]ering and increasing demand for more and more iron. [Cort's] inventions of Henry Cort carried us easily through [the] period of sharp trial, and, as his descendants after[ward] the principal cause of our success.

A single instance may show how great was the [revolu]tion effected by Cort's improvements. Richard Cr[awsha]y, one of the first of Cort's licensees, who was making [only] the hammer barely 10 tons of bar iron per week, [increased] his product by the process (concerning which he [wrote]: "I took it from a Mr. Cort, who had a little [mill at] Fontley, in Hampshire") to 200 tons per week. [Still] more significant still is the fact that, after the intr[oduc]tion of Cort's inventions the Admiralty specifica[tions,] instead of excluding English iron, called for it.

Lord Sheffield said in 1786, only two years after the date of Cort's second patent:

If Mr. Cort's very ingenious and meritorious improvements in the art of making and working iron, the steam engine of Boulton and Watt, and Lord Dundonald's discovery of making coke, should all succeed, it is not asserting too much to say that the result will be more advantageous to Great Britain than the possession of the thirteen colonies of America.

And in 1805, nearly eighty years later, William Fairbairn said:

Henry Cort's inventions have conferred an amount of wealth on Great Britain equal almost to six hundred millions sterling, and have given employment to six hundred thousand men.

III. CORT'S REWARD.

This chapter also I shall make as brief as possible. Not long ago I printed, for private circulation only, a "Review of the Case of Henry Cort," which I shall be glad to furnish to those who are seriously and sufficiently interested in its details. Here I shall confine myself to a bare statement of the essential facts.

For the purpose of obtaining additional capital, Cort made a business agreement with one Adam Jellicoe, a Deputy Paymaster in the Navy, whose son Samuel he admitted to a partnership in his business, in consideration of which the father advanced to the firm considerable sums of money, taking as collateral security for Cort's share in the firm's debt, an assignment of Cort's patents. The arrangement was fair enough on its face, but the moneys advanced under it by Adam Jellicoe had been stolen from the government funds, with the collusion of the Treasurer, Mr. Dundas, afterwards Lord Melville. That Cort had any knowledge of this circumstance there has never been either proof, accusation or suspicion.

The embezzlements of Adam Jellicoe had been carried on for years with the knowledge of the Treasurer and his Paymaster, one Trotter; but in 1788, under the pretense of a claim for repayment, these two forced him to surrender to them the Cort patents, which he held as collateral. Soon after (in 1789), Adam Jellicoe died; Lord Melville and Trotter instantly "discovered" his defalcation, and the latter, by a false affidavit, obtained an "extent" or summary attachment upon Cort's whole business and property.

At that time the amount of the alleged defalcation of Jellicoe, for which Cort was thus arbitrarily made responsible, was only £27,500. Cort was then executing a Navy contract for £15,000; and was receiving in royalties £15,000 per annum. Yet Trotter swore that he verily believed the said Henry Cort to be "much decayed in his credit and in very embarrassed circumstances," so that His Majesty could not recover "the aforesaid debt" without more speedy means than the ordinary process of the court. Accordingly Cort's property was seized.

After this seizure the patents were never seen; the contracts with licensees likewise disappeared, and so far as can be discovered, no royalties were ever collected under them. These royalties alone would have repaid the whole of the alleged defalcation within two years. But nothing was done to administer the property, and Cort was thus at one blow deprived without redress of all his earthly possessions—forge, mill, patents and royalties—in a word, completely ruined.

The amount of the royalties already covered by agreements would have amounted, at the date of Cort's death, to £200,000. If Lord Melville, who confessed the possession of the agreements, collected any part of this sum, he never accounted for it to the government.

Cort patiently sought to obtain justice, apparently without understanding the influences at work against him. He petitioned Trotter! he petitioned the Commissioners of the Navy; he petitioned Parliament; but was treated with indifference or insult. In 1794 a petition was addressed to the Prime Minister, William Pitt, praying that Cort might be appointed to some position in one of His Majesty's dockyards, or otherwise mercifully treated. This appeal brought a pension, netting him about £150 a year.

*From a paper read at the Lake Superior Meeting of the American Institute of Mining Engineers, and printed in the "Transactions."

†Pres., Morgan Construction Co., Worcester, Mass.

‡See Cort's British patents, Nos. 1351 (of 1783) and 1420 (of 1784); also a series of articles by Thomas Webster, an eminent authority on Patent Law, in the "Mechanics' Magazine," Vol. 2, London, 1839; Percy's "Metallurgy," "Iron and Steel," London, 1864, pp. 627-639; "Memoirs of Distinguished Men of Science," London, 1864, p. 152; Smile's "Industrial Biography," London, 1897, p. 114; Facts and Proofs Collected by R. Cort, London, 1855; and a partial summary, in my Presidential Address, "Some Landmarks in the History of the Rolling-Mill," delivered before the American Society of Mechanical Engineers, at the New York meeting in December, 1900, and published in Vol. XXII. of the "Transactions" of that Society.

‖As to puddling, Thomas and George Cranage (British patent, No. 851, of 1766) and Peter Onions (No. 1,370, of May, 1783). Since Cort began experimenting in 1777, the date of the latter is not proof of priority of invention. There is no evidence that either of them was commercially practiced. Concerning the use of grooved rolls, I think Cort's originality is not denied.

*July 29, 1856.

After his death his widow received net £100 a year, and later, on her decease, the two unmarried daughters received per annum £25 6s. each, "subject to reductions," or probably about £20. And this was doled out to a man from whom the government had taken more than £200,000 to repay a defalcation of £27,500, of which he was never even accused of having any knowledge!

But the greatest outrage was yet to come. In 1800, Henry Cort died, and as soon as he was out of the way, and his infant children were incapable of asserting their rights, Lord Melville presented a memorial to the Lords of the Treasury, setting forth the great merit and value of Cort's inventions, and asking on that account that he himself should be released from £25,000 of the Jellicoe defalcation, for which he held himself responsible! This petition was promptly granted; and presumably the Cort patents were turned over to the government and cancelled.

In 1806 Parliament appointed a Commission of Inquiry to examine the irregularities of the Treasurer, Lord Melville, and his Paymaster, Alexander Trotter; but these two worthies burned their accounts before they could be examined. The documents in the Cort case were destroyed with the rest. Upon his impeachment and trial (the amount of the defalcation of £25,000 having been made good in 1800, as stated above) Lord Melville was acquitted by a vote of 88 to 47 peers! In other words, a high official of the British Government had stolen money from its Treasury; the Government connived in his attempt to shield himself by robbing an innocent citizen, under the forms of law, abnominably misused for that vile purpose, not only the patent rights which the Government had solemnly covenanted to protect, but also all other property of the innocent victim, were thus stolen from him by arbitrary process and without legal redress; and finally, as a climax of this performance, the original thief was rewarded, in consideration of the great value of the plunder, of which the Government of Great Britain then became the receiver!

It seems justly clear, however, that the Government treasury received no pecuniary benefit from this crime. It had been robbed by Lord Melville, and it credited him with the value of the proceeds of another robbery, which he transferred to it; but, so far as can be discovered, it did not realize any part of this value by collecting from Cort's licensees the royalties they were pledged to pay. Consequently, the beneficiaries of the outrage, next to the titled criminal (and to a far greater pecuniary extent), were those who were thereby released from the payment to Cort of the royalties (amounting to $1,000,000) which they had agreed to pay him, and, next to these, the manufacturers who, during the term of Cort's patents, used his inventions without even agreeing to pay royalty, and were never called upon for such payment. In view of the rapid extension of the practice of these inventions, thus prematurely thrown open to the public in total disregard of the inventor's guaranteed rights, it is a safe estimate that $2,000,000 more was saved to somebody. Whatever may have been the injustice of the summary proceeding by which Cort was robbed and ruined, it was clearly the duty of the Government, as the holder of the patent-rights and other property which it had seized, to administer them, and account for the resulting revenue. There is not the least trace that this was ever attempted; and in view of the revealed character of Lord Melville (which the whitewash applied by the Peers cannot hide), it is hard to believe that immunity from those payments of royalty under Cort's patents, which he could have enforced, was not bought from him by bribery.

Unfortunately, there is evidence confirming this suspicion of shameful treachery and falsehood on the part of some of the ironmasters who apparently profited by the remission of royalties and the practical cancellation of the Cort patents. In 1812 a petition for a parliamentary grant to Cort's family, in reward for his services to his country, was presented in the House of Commons, with a recommendation from the Prince Regent. It was referred to a committee, of which the son of Lord Melville was a member. Two ironmasters were heard against the petition. Their evidence could have been easily overthrown, but the committee, excluding all evidence in contradiction or explanation of their statements, suddenly closed the investigation, and reported to the House that, though a considerable share of merit was due to Henry Cort, they could not satisfy themselves that it was sufficient to entitle the petitioner to a Parliamentary reward.

The testimony of the two false witnesses aroused much public indignation, and within a few weeks after the inquiry the chairman of the committee received a mass of evidence, concerning which he calmly said that "if it had been in time, the report of the committee would have been very different. Yet the children of Henry Cort were never able to get this evidence further considered. Even the recommendation of the committee of a grant to cover the expense of their futile petition for justice was ignored; and this amount was calmly charged against their penury.

The last chapter in this long story of wrong is the petition of Richard, the only surviving son of Henry Cort, presented to Parliament in 1856. Direct result it had none, so far as I know; indirectly, it was probably the cause of the grant to Richard Cort by Lord Palmerston, then premier, of an annuity of £50 (all previous Cort annuities, with their "reductions," having lapsed).

IV. OUR UNPAID DEBT TO CORT.

Samuel Smiles, in his biography of Cort, says:

"While the great ironmasters, by freely availing themselves of his inventions, have been adding estate to estate, the only estate secured by Henry Cort was the little do-Hampstead churchyard."

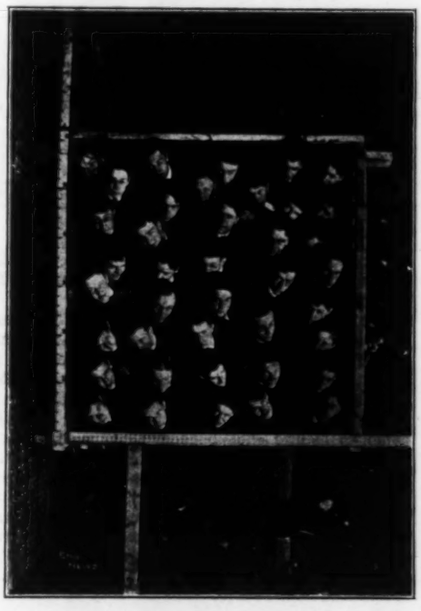
During a recent visit to England, I tried to find that "little domain." The sexton of the church knew nothing about it; but after the entry of the burial had been found by examination of the records, a renewed search discovered at last the grave. The headstone was weather-worn, and the inscription upon it hardly legible. It seemed as if inanimate things had conspired to perpetuate the obscurity and neglect wrought by the malice of man.

I have had this stone cleaned, and have obtained permission from the parish authorities to place in the Hampstead church a bronze tablet in honor of Henry Cort, bearing a life-size bas-relief bust of the inventor.

When our English brethren are ready to erect the larger monument which Henry Cort deserves, no doubt we shall all be glad to cooperate with them. Meanwhile, one American, at least, has had the opportunity and privilege of expressing in an enduring form, for the encouragement of other meritorious, though defeated heroes, the assurance that, sooner or later, history will do them justice, and succeeding generations will not let them be forgotten.

THE WEIGHT OF CROWDS.

An instructive series of experiments on the weight of congregations of people was reported in Engineering News of April 14, 1904, by Prof. L. J. Johnson, of Harvard University, Cambridge, Mass. The experiments showed that a loading of 150 to 160 lbs. per sq. ft. of floor may be produced by the weight of an assembled group of persons without intolerable crowding. Other observers have reported loadings nearly as high.



View Looking Down on a Crowd Weighing 181.3 Lbs Per Sq. Ft.

Experiment of Prof. L. J. Johnson at Harvard University, Cambridge, Mass. Enclosure 6 Ft. Square = 36 Sq. Ft. 40 Men, Average Weight 163.2 Lbs.

Kernot*, of Melbourne (Australia), Spofford†, of Boston, and Hunscheidt‡, of Bonn (Germany), succeeded in producing loadings of 143, 142 and 144 lbs. per sq. ft. respectively. In all these cases the experiment was such that exceptional conditions—as, for example, forcible compacting—were absent, and none of the three observers carried the experiment even as far as the practicable limit of crowding.

Professor Johnson recently repeated his experiments in more careful and comprehensive manner, using a square high-walled enclosure or pen 6 ft. on a side, 36 sq. ft. in floor area, and photographing the group of persons assembled within it at various degrees of crowding.

*Engineering News, March 16, 1893, p. 252.
†Engineering News, May 5, 1904, p. 426.
‡Engineering News, Nov. 3, 1904, p. 406.

The view shown herewith represents the condition of maximum crowding reached in this series of experiments. The enclosure of 36 sq. ft. area contains 40 men, averaging 163.2 lbs. in weight. The unit loading on the floor is

$$\frac{40 \times 163.2 = 6{,}528}{36} = 181.3 \text{ lbs. per sq. ft.}$$

This figure is unparalleled in the records of observations on floor-loadings. It is an extreme figure, but one which may often be reached in dense crowds gathered at random. The men in the enclosure reported no serious discomfort, and except for their being tall men, "selected with some care" from a larger class, there is nothing in the experiment that may not be duplicated in the central part of a large crowd. It will be seen from the picture that the men face in one direction; this condition favors maximum compacting, but at the same time it is the arrangement which would occur in a natural crowd.

A report of Professor Johnson's experiments, illustrated with views showing various degrees of crowding up to the maximum here pictured, may be found in the Journal of the Association of Engineering Societies, of January, 1905.

THE SIBERIAN RAILWAY.

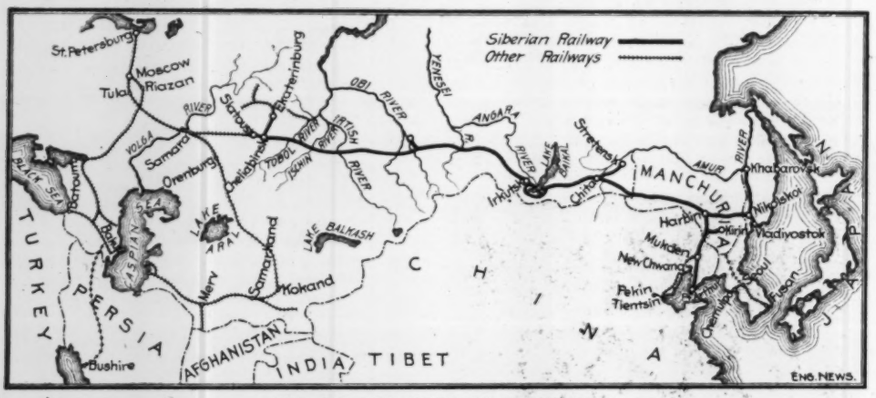
The great Siberian Railway, built by the Russian Government to develop Russian territory which was practically inaccessible, and to form a military and pioneer line connecting European Russia with its possessions on the Pacific, has always been a matter of engineering interest, and is now of special interest in its relation to the war in Manchuria. An article discussing this railway (before its completion) appeared in our issue of Nov. 10, 1896, and we give herewith an abstract of a paper by Mr. Metin, published in the "Revue Economique Internationale."

Starting from Moscow there are two lines, one of which is double track as far as Raizan, 124 miles; the other is double track as far as Toula, 121 miles. These lines unite as they approach the river Volga, forming one single track line, crossing the Volga by the Alexander bridge a short distance west of Samara. This bridge is a steel structure about 4,850 ft. long, built in 1880. The line from Samara to Zlatoust, 580 miles, was built between 1873 and 1880, crossing the steppes and crossing the wooded mountains of the Ural range without tunnels by means of long grades and switchbacks. The terminus of this line is on the eastern slope of the range, 1,330 miles from Moscow, and here begins the Siberian Ry. proper. The first section of the Siberian Ry. extends from Zlatoust to Baikal lake, and is 2,055 miles long. The second section extends from the lake 740 miles to the frontier of Manchuria. Thence the Chinese Eastern Ry. extends across Manchuria to Harbin, 5,000 miles from Moscow. From Harbin there are two lines, one to Vladivostok, and the other to Port Arthur, 5,383 miles and 5,500 miles respectively from Moscow. In connection with this main trunk line are some auxiliary lines: (1) the branch from Cheliabinsk to Ekaterinburg, 152 miles, connecting with lines to other points; (2) the 60-mile branch to Tomsk, the largest city in Siberia; (3) the two portions of the line originally projected to be built entirely within Russian territory (before the Chinese Eastern Ry. across Manchuria was projected); this line was to be a continuation of the second section down the valley of the Amur river. The first of the portions actually built is from Chita east 175 miles to Stretensk, which is the head of navigation; the other portion extends from Nikolsky (near Vladivostok) northward down the Ussuri River to its junction with the Amur at Khabarovsk (340 miles). Communication between the eastern and western sections of the main line at Baikal Lake was originally maintained by steam ferries, owing to the time and cost of construction of the connecting line around the south end of the lake. This line has now been built, however, and was described in our issue of Nov. 17, 1904.

All these lines have the Russian gage of 5 ft.; they belong to the government and are operated under the direction of the Minister of Communications. Those of the Siberian Ry. proper have

been built during 1896 to 1900; while the Chinese Eastern Ry. was built between 1900 and 1902. Work was commenced wherever material could be collected, namely, at each end and at the crossings of navigable rivers; the stretches of line were built between these several points, and then connected up by bridges. The orders were to build the line as quickly and as cheaply as possible, necessitating economies in time, work and money, at the expense of stability. The width of single track roadbed for Russian railways is 18.20 ft., but on the Siberian Ry. the width is only 16.40 ft. on banks and 15.41 ft. in cuts. The ballast is only 10 ins. thick, instead of 18.8 ins., and is used only on grades; on level track the ties are often laid on the roadbed, with an additional tie to each rail length. The ties are not creosoted or otherwise treated. The rails weigh only 48 lbs. per yd., instead of the standard 64 lbs. The large bridges are of steel, but all others are of wood. This style of construction gives a very inferior line, on which trains can only run at low speeds.

The western section of the line, between the Ural Mountains and Lake Baikal crosses rolling plains, with lakes of fresh and alkaline water. The land is alluvium and sand, not furnishing good ballast. Then follows the marshy plain of Baraba about 260 miles, where the banks are



MAP OF THE SIBERIAN RAILWAY.

subject to slips and have the slopes protected at several points. These two stretches of plain extend to the Obi River, and in crossing them the railway has 56% of its length on the level and 92.5% on tangent. West of the Ural, on the Volga plains or steppes, these proportions are 39.82% on the level, and 71.24% on tangent. From the Ural Mountains to the Obi River the earthwork has averaged only 23,500 cu. yds. per mile. The only serious obstacles to construction were the rivers: The Tobol is crossed at Kourgan by a bridge 1,400 ft. long; the Ichim at Petropaviosk, 700 ft.; the Irtish at Omsk, 2,100 ft.; and the Obi at Krivochekovo, 2,650 ft.

Between the Obi and the Yenesei Rivers, the proportion of level line is reduced to 35%, and the proportion of tangent to 70%, while the earthwork is almost twice as heavy, owing to the broken character of the country, which lies among the foothills of the mountains to the south. The ground is marshy, and at one place an opening for the railway had to be burnt through the dense forest for 165 miles. There are many small viaducts and heavy banks, as well as numerous important steel bridges. The largest of these latter, and the longest bridge in Siberia, is that across the Yenesei River at Krasnoiarsk, 2,860 ft., with six steel spans of 475 ft., on granite piers. From the Yenesei River to Irkutsk the proportion of level line is 33%, and that of tangent 68%. There are no tunnels, but steep grades and sharp curves are employed among the hills. For 158 miles there are frequent grades of 1% and curves of 1,050 ft. radius (as against 0.7% and 1,814 ft. on the previous section). The maximum grades are 1.75% and the sharpest curves 840 ft. radius. The mountains become higher as the line approaches Baikal Lake, which is 400 miles long and 28 to 40 miles wide. The city of Irkutsk is 37 miles west of the lake, on the Angara River, and here the old mail route turns south to pass around the lake, but in view of the difficulties and cost of building a railway parallel with this route it was decided to follow the Angara River to the lake and to introduce a steamer service. Prince Hilkoff, who was then (and is still) Minister of Communications, had had a technical education in the United States, and he introduced a service of ice-breaking train-ferry steamers, similar to those in use on the Great Lakes. The first of these was the "Baikal," built in England, re-erected on the lake, and making its first trip in April, 1900. It is 292 ft. long and 57 ft. wide, with three tracks on the main deck and accommodation for 300 passengers on the upper deck. It has engines of 3,750 HP., driving two screws at the stern and one at the bow, and has a speed of 13 knots. Two of these boats were proposed, but lack of available funds prevented the construction of the second. As two boats were necessary, a smaller ice-breaker was built to carry passengers and freight, but not trains. This boat, the "Angara," made its first trip in August, 1900. It is 200 ft. long and 35 ft. beam, with engines of 1,250 HP. These two steamers are in service for eight months of the year, April to December. When the lake is covered by thick ice, the crossing is made by teams or by cars drawn on a railway track by horses, but the ice is very treacherous and often cracks or breaks. The construction of the connecting railway around the lake was decided upon in 1902, as a result of the Boxer war in China.

The eastern division of the Siberian Ry., extending from Baikal Lake to the Amur River and the Manchurian frontier, lies almost entirely in mountainous country, and the maximum grades and curves (1.7% and 840 to 1,050 ft. radius) are frequently employed. The line was built with the same haste and cheapness as the line across the plains, and had a narrow roadbed, light rails, little ballast, and few sidings, repair shops and engine houses. Some portions in the valleys of tributaries of the Amur were built too near the rivers, with the result that extensive washouts occurred in time of flood. The Chinese Eastern Ry. (or Manchurian section) crosses the Khing-han mountains, and has several tunnels, one of which is 10,145 ft. long. It then descends into the irrigated and cultivated basin of Harbin, crossing the Sungari river and its tributaries by large steel bridges 3,110 ft., 2,410 ft. and 2,130 ft. long. The branch to Vladivostok has some tunnels in crossing the Little Khing-han range, but on the branch to Port Arthur there was little difficulty in crossing the low range separating the Harbin basin from the Mukden basin, which latter is the most fertile and densely populated part of Manchuria.

The cost of construction seems to be very high. From the Ural mountains to the Obi river, crossing the plains, the cost was $27,200 per mile; from the Obi to Irkutsk, $46,500; from Baikal lake to the Amur river, $60,000. On the portions more substantially built the cost rose to $76,600 per mile between the Amur and the Manchuria portion, and $84,000 per mile for the several lines in Manchuria. The average cost for the whole line was $54,200 per mile. This is exclusive of the Baikal lake section, which averaged $167,700 per mile, and reached a maximum of $210,000 per mile on the difficult western section between Baikal Station and Kultuk. In Europ[ean] Russia the average cost of railways is $31,5[00] per mile. One reason for this high cost is the [high] quality of labor in Siberia. The two ice breake[rs] and a floating dock on Baikal lake [docks] $3,507,500. [about]

As the work extended further from [the] Volga, less of the work was done by contract. T[he] proportion built by contractors was 85% [between] the Volga river and the Ural mountains, [and] thence to the Obi, 56% thence to Irkutsk, an[d] 28% east of Baikal lake. All the remai[ning] of the work was done by the administration. [Workmen] were as hard to get as contractors, a[nd the] government employed several thousand [hands] on the work. But these were quite insuffi[cient], and it was necessary to get men from th[e prisons] of Siberia and even from Russia. This i[ncreased] the establishment of great camps and ba[rracks], and the men had to be clothed and fed. [Few Rus]sians are masons and stone workers, and [therefore] Italians, Greeks and Roumanians [were em]ployed for the bridge and tunnel work and the building of retaining walls. The wages paid to these foreign employees were very high. Materials also were very costly; stone and wood were found, but had to be transported great distances to reach many parts of the line. Iron and steel was sent from Russia by land and by sea.

The light rails and other expedients for cheapness of construction have long been condemned. The newest sections of the line, around the Baikal lake and across Manchuria, were constructed more substantially that the others. Standard 64-lb. rails are replacing the old rails, additional ballast is being laid, and light wooden bridges are being replaced with stone or steel structures. Additional stations, sidings, engine houses and repair shops are being built. All these works are carried on without interfering with the traffic, which is carried around them on temporary tracks. With the heavier track and structures the traffic has been increased, and in August last there were 12 military trains daily from Russia as far as Irkutsk; each train had 30 to 35 cars. In 1903 there were on the whole line 1,514 locomotives, 2,588 passenger cars and 27,508 freight cars. Since the commencement of the war, engines and cars have been sent from other Russian lines, and at various places cars are built with wood from the Siberian forests, and wheels and underframing sent from Russia. Wood is used for fuel on the eastern division, between Baikal lake and Manchuria; but on the western division, between the lake and the Ural range, wood has been superseded by coal, partly from Siberian mines. On the Manchurian line both wood and coal were used while the Russians held the mines, but this supply is now cut off and only wood is obtainable.

On the western division there are 11 or 13 trains daily, carrying troops and supplies, and the troops forwarded average 1,500 to 1,600 per day. This number could be increased on emergency by delaying the supply trains. All regular trains have been withdrawn, but there is a mixed train daily on certain sections, and a mail train daily over the entire division, while four days a week there is a special fast train making the trip to Irkutsk in 7½ days. From Irkutsk the cars of supplies are sent on to the lake, and run upon the large transfer steamer which is reserved for military service. This makes four trips daily in both directions on the shortest route, Baikal to the new landing at Tankoi, the end of a branch of the line around the lake. It takes 100 cars each trip and also carries 1,000 soldiers eastward. The smaller steamer makes one trip a day in each direction on the longer route from Baikal to the old landing at Myssovaia, carrying passengers and hauling barges loaded with freight. The easier eastern section of the line around the lake was built first, and until the western end was completed the troops and horses were sent by the mail road from Irkutsk to Kultuk (the temporary head of the new line), where they boarded trains for Manchuria. On the eastern division of the line there is only one passenger and freight train daily, besides the military trains; while the Manchurian line is devoted entirely to military purposes. The transportation of troops from Russia to their destination in Manchuria takes at least six weeks.

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The unsatisfactory quality of modern heavy steel rails has been brought out at several meetings of the American Railway Engineering and Maintenance of Way Association, and at the meeting last week steps were taken which, it is hoped, will produce important results. The specifications adopted by the Association provide that the test pieces shall "preferably" be taken from the top of the ingot; but it appears from the evidence of the railway engineers and the manufacturers that the test pieces are, as a matter of fact, generally taken from the bottom where the steel is denser and where piping is not likely to be met with. The Association has now voted to eliminate the word "preferably," thus making it obligatory upon the manufacturers to take the test piece from that end of the ingot where the poorer quality of steel is met with. If this can be enforced, it will mean that more care will be taken in the manufacture, or that a larger proportion of the top of the ingot will be cut off and discarded. The defective character of heavy modern rails seems to have been well established, and in view of the dangers as well as the expense involved, railway engineers are making strenuous efforts to compel the rail mills to furnish rails of better quality. As to their ability to produce such rails, there can be no doubt, and it is time managers of some of our great steel producing plants were made to understand that a safe product, satisfactory to the purchaser, is even more important to permanent prosperity than the payment of dividends on over-diluted stock.

What is a reasonable price for a franchise-holding corporation to charge for its services? In all the discussion on the subject it is seldom that this question is fairly faced. A gas company or an electric lighting company or a water company claims that its rates are reasonable, but it says nothing as to what the reasonableness of the rate consists in, and it denies all opportunity for determining whether its claims are well founded. On the other hand, the public and its would-be defenders in the Courts or City Councils or State legislatures denounces rates as extortionate; but fails to prove the extortion.

In refreshing contrast to this usual and ordinary procedure is the action just taken by the New York Telephone Co. There has been much talk of late concerning legislation to arbitrarily reduce the rates charged by the company for its services. Whether it was inspired by legislators desiring to serve the public or to "work for their own pockets all the time," does not appear, and for the present purpose is of no importance, since in either case none of the legislators knew or could possibly know whether the telephone rates charged in New York City were in fact reasonable or not.

Instead of joining in the hue and cry for lower telephone rates, the Merchants' Association of New York City took up the matter of telephone rates directly with the company. What was actually done is stated as follows in a document issued by the Association:

> In May last the Merchants' Association of New York began an investigation of this subject with a view to learning whether or not the present telephone charges in this city are just and reasonable, and with the further purpose of taking such action as might be necessary to secure a proper reduction in case it was found that the charges were unjust.
>
> At the outset a stipulation was entered into with the officials of the New York Telephone Co. whereby they agreed to afford the committee of the Merchants' Association all reasonable and proper assistance in the inquiry proposed. The committee proceeded to make an exhaustive examination into the telephone charges of other cities as a basis of comparison, and also accumulated a large body of data relating to the necessary cost of construction and operation of telephone service in various cities. Incidental to this inquiry it had the benefit of the expert advice of Messrs. Westinghouse, Church, Kerr & Co., a firm of electrical engineers of international reputation, and the immediate services of Mr. A. V. Abbott, for nine years chief engineer of the Chicago Telephone Co., and one of the foremost telephone engineers of the day.
>
> After accumulating these general data the committee availed itself of the offer of the New York Telephone Co. and entered upon an examination of the investment, equipment and operating accounts of that company, and of its gross and net earnings, with a view to determining the reasonableness of the charges for telephone service in this city. The committee was afforded by the telephone company every reasonable facility for making the examination desired, and was further authorized to verify the statements submitted to it relative to the accounts of the company, through a firm of public accountants of highest standing and of our own selection, in order that the latter might give a certificate of the accuracy of the accounts so inspected.
>
> At an early stage of its negotiations the committee reached an agreement with the telephone company as to the percentage of profit which would be considered fair, and its further investigations have been directed to ascertaining what the actual profits of the telephone company are, with a view to their reduction to the agreed percentage, if found materially to exceed the figure agreed upon. The examination is not yet complete, but is still in active progress. The results thus far obtained are entirely satisfactory to the committee, and it is the conviction of the committee that the final results of its work will be satisfactory to the public as well.

Since this statement was issued the company has announced a reduction in its rates for telephone service, which is stated to be entirely satisfactory to the Merchants' Association Committee.

We think this plain, straightforward, honest and business-like procedure cannot be given too wide publicity. The managing officers of the New York Telephone Co. are deserving of the greatest credit for the broad and liberal manner in which they have treated the subject. It is in such extreme contrast to the common method of conducting public service corporations that it cannot be too highly commended.

What are reasonable rates for telephone service or water supply or gas or electric current or street railway transportation or any other public service furnished by franchise-holding monopolies? They are such rates as will yield a fair return on the capital actually invested, after paying all expenses of operation, depreciation, etc. Rates that yield more than this are an extortionate tax on the public. Rates that yield less are unfair to the investors of capital.

We commend the action of the New York Telephone Co. to the managers of public service corporations generally. Whenever and wherever they are ready to adopt a similar policy toward the public, they will find the public ready to meet them on a fair basis. But so long as they maintain the stand that their business is a private business and that they have a right to "charge what the traffic will bear," so long will they be the legitimate target of strike legislators and aldermen and of blackmailing attempts at competition.

We called attention some months ago to the strong tendency now apparent to discard great trainsheds with lofty steel roof-arches at railway terminals and use instead open tracks with the platforms between protected by umbrella roofs. It will be seen by the article on pages 327, 328 of this issue that this plan has been adopted for the large new passenger terminal at Sydney, which will be probably the most important railway passenger station in Australia. It is also to be used at the great new passenger station at Washington, D. C., and at the new Hoboken terminal station of the Lackawanna R. R.

All things considered, it looks as if the mammoth trainshed had had its day. Of course, there are bound to be more or less complaints of the umbrella platforms, particularly in severe winter weather; but if it is deemed necessary to build enclosed trainsheds, it is likely to be done by a succession of parallel building of moderate height and roof span. Such structures it may be possible to build of reinforced concrete so as to be proof against the action of locomotive gases.

In our issue of Feb. 9 we published descriptions of four notable dams of unusual construction. In the present issue there is described a dam of which one section consists of a core of gravel and macadam covered with an 18-in. layer of concrete, and exposed to the flow of water through a series of large regulating gates. The design is certainly an exceedingly bold one, and engineers will watch with interest to see how it endures the impact of high floods.

The American Railway Engineering and Maintenance of Way Association held last week its sixth annual meeting, and a report of the proceedings is given elsewhere in this issue. We cannot refrain from expressing disappointment at the evident falling off in the technical value of the work done by the convention. This was due not to any lack of interest on the part of the members, for the attendance was good, and the sessions were long; nor was it due to any neglect of work on the part of the committees, for a dozen of them presented extended and valuable reports. The reason was that a large part of the sessions were spent in discussing trivial matters (as happened at the 1904 convention), and that the important matter presented was too great in quantity to be properly handled in the time available. At the meeting, last week, there were 13 reports from 17 committees. Of these 13 reports, 11 were considered and two were read by title. This looks, on the face of it, like a good record, but the fact is that the convention spent the first two days and a part of the third on three reports only, leaving the other eight to be rushed over in a perfunctory manner at two sessions.

One defect in the conduct of the proceedings, as at some of the former conventions, was in devoting entirely too much time to the consideration of definitions. The Board of Direction has held, from the first, that the committees should prepare definitions of technical terms used in the several fields of investigation covered. Some of the committees have confined themselves to a comparatively small number of significant and important terms. Others have prepared lengthy lists of words and terms of all kinds. As we pointed out a year ago, it is not every man who has the facility of preparing definitions which will be clear, concise and authoritative. The natural result is that these lists of definitions are largely indefinite and in many cases incorrect; open discussion does not effect much improvement, and after much waste of valuable time the definitions still remain unsatisfactory, while those present are too tired to properly discuss more important matters. The association had 13 large and important reports before it for consideration, yet it devoted hours of valuable time to the interchange of opinions as to how to word definitions of the various parts of timber trestles. We criticise this feature of the convention in no unfriendly spirit, but because it has been very much in evidence

before, and is liable to result injuriously to the reputation of the association. We recognize this association as one which possesses great possibilities of usefulness, and its committees have done a great amount of valuable work; but it is exceedingly discouraging to members who devote valuable time to such committee work to have the convention pass it over in a perfunctory way, and practically leave the committee's work without result.

The Civil Engineers' Club of Cleveland adopted a most commendable plan in celebrating recently the 25th anniversary of its foundation. Besides holding a silver anniversary banquet on March 13, it has issued a handsome little memorial volume in which is briefly related the story of the club's organization and early history

The recital of those events of twenty-five years ago brings clearly to mind some of the men who played a prominent part in them and who are no longer with us; and the whole is such a valuable bit of engineering history, known now, however, to very few of the present generation of engineers, that we have deemed it well worth while to reprint the first portion of this little volume, as follows:

Early in 1880 Mr. Charles Latimer, Chief Engineer of the Atlantic & Great Western Ry. (now a part of the Erie System), organized a society which had for its object the study of the Great Pyramid, and also to combat the introduction of the metric system.

About this time a little coterie of engineers, namely, Messrs. C. H. Burgess, County Surveyor; Walter P. Rice, Asst. U. S. Engineer, and Hosea Paul, Civil Engineer, were in the habit of meeting occasionally at the office of the first named gentleman in the court house, and discussing current events. At one of these informal talks it developed that each had been invited to join the new organization and had declined, for much the same reasons.

While acknowledging that the Great Pyramid was deserving of study by the historian and the archaeologist, if not the engineer, they could not attach to it any mystic or religious significance of present value; pyramidal dimensions, and their reputed coincidences with mathematical laws or physical incidents, did not appeal to them. As for the metric system, so far from being opposed to it, they, in common with most of the younger school of engineers, believed thoroughly in a decimal system, and further believed the metric system to be a distinct improvement on the English system of weights and measures.

With these ideas in common, the three gentlemen held several conferences on the subject of organizing a society to advocate the metric system. An examination and inquiry into the number of individuals engaged in engineering and allied pursuits reached such a large total that the inspiration came to them that it was possible to organize a society on a broader basis, the importance of metric system advocacy being made secondary to the idea of a permanent engineering society in the city of Cleveland. The originators readily enlisted the hearty cooperation of such gentlemen as Messrs. Charles A. Walter, J. S. Oviatt and S. J. Baker, of the City Civil Engineer's Department, and Messrs. Aug. Mordecai, John Wainwright, Gustav Lindenthal and Arthur M. Wellington, at that time constituting Mr. Latimer's engineering staff on the Atlantic & Great Western Railway. Under the able guidance of the above gentlemen, with Messrs. Rice, Burgess and Paul, first named, ten in all, an organization of the engineers of Cleveland was subsequently consummated.

February 28, 1880.—On this date the first regular organization of the civil engineers of Cleveland was effected at the office of the county surveyor, in the new court house on Seneca St.

The records show that the following gentlemen were present: Walter P. Rice, Hosea Paul, C. H. Burgess, S. J. Baker, C. A. Walter, A. Mordecai, J. Wainwright, G. Lindenthal, J. S. Oviatt, J. B. Davis.

March 9, 1880.—Constitution and by-laws adopted, except as to name of organization.

March 13, 1880.—Large accession of members. Name of "The Civil Engineers' Club of Cleveland" adopted.

Officers elected: President, Charles Paine; Vice-President, A. Mordecai; Corresponding Secy., Walter P. Rice; Recording Secy., C. H. Burgess; Treas., C. A. Walter; Committee on Library and Publication, Hosea Paul, M. E. Rawson, H. M. Claflen; Committee on Program, G. A. Hyde, E. O. Schwagerl, Wm. Reuschel, A. M. Wellington, C. M. Barber.

March 27, 1880.—Special meeting at the Board of Education rooms. Public invited. Inaugural address by President Charles Paine. Addresses by Col. J. M. Wilson, Col. Chas. Whittlesey, Hon. Geo. H. Ely, Prof. John White, Rev. J. W. Brown.

April 3, 1880.—Resolution by Water P. Rice suggesting the joint publication of proceedings with other similar societies.

July 3, 1880.—A. M. Wellington presented plan for joint publication. Subject referred to Committee on Publication and Library with President Paine and Mr. Wellington.

December 4, 1880.—After extended correspondence, a meeting was held in Chicago on Dec. 4, 1880, for the purpose of deciding finally upon articles of association, Messrs. A. M. Wellington and M. E. Rawson representing the Cleveland club. These articles assured the assent of the following societies: Boston Society of Engineers, Jan. 19, 1881; Engineers' Club of St. Louis, Jan. 5, 1881; Civil Engineers' Club of Cleveland, Jan. 8, 1881; Western Society of Engineers, April 5, 1881. This action of the several societies augmented by the appointment of a board of managers established the Association of Engineering Societies.

June 11, 1881.—Articles of "The Association of Engineering Societies" adopted, and the publication of the "Journal" of the association authorized at a meeting held in Cleveland this date.

A. M. Wellington was appointed manager for the Civil Engineers' Club of Cleveland, and upon his resignation April 2, 1881, to fill a professional engagement in Mexico, Mr. M. E. Rawson was appointed to the vacancy.

March 12, 1881.—Annual meeting. Mr. Chas. Paine re-elected President of the club.

April 2, 1881.—First meeting of club in new rooms in the Case Library Building.

September 14, 1881.—Resignation of Charles Paine, as president of the club, to accept an important position on an eastern railway.

November, 1881.—First number of the "Journal" of the Association of Engineering Societies published. Contained the inaugural address of President Paine, and a paper on pavements from a member of the Cleveland club.

The year 1905 is the 25th year of the "Journal's" continuous publication.

March 11, 1882.—Colonel Jno. M. Wilson, U. S. A., elected president of the club.

September 12, 1882.—Colonel Jno. M. Wilson tendered his resignation as president, owing to his promotion and transfer to headquarters at Washington. J. F. Holloway elected president in 1883, Charles Latimer in 1886 and Jno. Whitelaw in 1887. Each of the last three is now dead. All the other past presidents are still living, and with one or two exceptions are all in active business.

So far as we recall, the above recorded action by the Civil Engineers of Cleveland in arranging for joint publication of their proceedings with other engineering societies, was the first instance of formal cooperation between different associations of engineers.

We cannot mention here the founding of the Association of Engineering Societies without calling to mind also the remarkable work begun and carried on for years by the late Prof. J. B. Johnson, of the St. Louis Engineers' Club, in connection with the Association's "Journal," of an index to current engineering literature. It was, we believe, the first attempt of this sort ever made, and in some respects the work has not been so well done by anyone since. Few engineers in this country have done so much for the benefit of their profession as was done by Prof. Johnson in his all too-brief life.

While the first idea of organization of the Cleveland Club grew out of opposition to Mr. Charles Latimer's "anti-metric" society, Mr. Latimer himself became the club's fourth President. The younger engineers who were associated with Mr. Latimer might be amused at such of his eccentricities as his anti-metric crusade, but his sterling character and sincerity of purpose were such as to win their genuine respect and affection in common with all with whom he came in contact.

Recent discussions have emphasized the importance of recording the current history of engineering and writing down also the history of the recent past while those still live who are able to do it from personal recollection. This is, we believe, a work which the engineering societies might do and should do to a very much larger extent; and with more attention to the personal side of the record than is often given. The Cleveland Club's little anniversary volume is a modest venture in this direction which is well worthy of imitation.

SHOULD AN ENGINEER INVARIABLY ACCEPT WORK THAT HAS BEEN ACCEPTED BY HIS INSPECTORS?

A correspondent, whose letter appears in this issue, discusses the employment of inspectors for public works. The duties of an inspector and the limitations to his authority should be set forth in the specifications, as we have pointed out several times before; but there are certain other features relating to inspection that are well worthy of careful consideration. Our correspondent, for example, raises the question of appointment and urges the desirability of selecting inspectors who come with the endorsement of local politics. There are many engineers whose experience with this kind of inspectors has not been such as to lead them to commend this method of selection. On the other hand, it is true that young engineering graduates often exercise an arbitrary control over the methods of doing work, causing waste and unnecessary increase in cost to contractor. On the whole, however, the engineering graduate is to be preferred, even with his faults, because he is seldom dishonest. Honesty is the one indispensable attribute of an inspector worthy of the name.

With a perfectly definite specification there would be few complaints from contractors against the rulings of inspectors. As things now stand, complaints are frequent, and often justifiable. The reason for this state of affairs is the lack of definiteness so characteristic of engineering and architectural specifications in general. A good example of this occurs to us. Specifications for a masonry wall called for stone that should come up to the following lucid (?) requirement:

The stone must be of limestone, sandstone or granite, of quality, size and shape acceptable to the Engineer.

The contractor opened a quarry of thin-bedded silicious limestone. The stone had not proved to be a very durable stone, as shown by the condition of some which had been used in old local structures, but it was the best local stone available. To get anything better would have required a long and expensive haul by rail, and an equally expensive haul by wagons after delivery at the nearest station. This contractor quarried and delivered about 1,000 cu. yds. of the local stone, which was accepted by the inspector—a young man appointed by the Engineer to oversee the construction. Just before the weather moderated sufficiently to permit beginning the laying of the masonry, the Engineer visited the work, examined the stone and condemned all of it as unfit, because it was not "acceptable to the Engineer."

The Engineer was frank enough to admit that a great hardship was thus imposed upon the contractor; still he felt justified in his action by the knowledge that the stone would not be durable, and he consoled the contractor by telling him that he should have forwarded samples of the stone for examination, instead of relying upon the inspector, whose decision, in any case, was not final. Was the Engineer right in his ruling? After appointing an agent to act for him as inspector, was he right in reversing the ruling of that agent?

Another similar example was recently cited by an engineer. A sub-contractor had laid a mosaic floor in a government building. The floor had been accepted by the inspector, who was constantly present during the work. Finally the Engineer arrived and condemned the whole floor because the cement joints between the tiles were a trifle thicker than he deemed "acceptable." The floor was all torn out and relaid. The sub-contractor was ruined. Was this a justifiable ruling on the part of the Engineer?

In each case the Engineer had failed to be definite in his specifications, but after the work was done—then he was definite with a vengeance.

In the one case, the Engineer should have clearly stated in the specification whether or not local stone would be acceptable. Indeed, considering the magnitude of the work, he should himself have quarried samples of the rock to determine its suitability for the work in hand, if any doubts existed on that score.

In the other case, the Engineer should have specified some standard of acceptable workmanship in mosaic, by reference to existing floors, or otherwise, if he had any definite ideas on the subject.

In both cases the engineers were directly at fault in having failed to specify in such a manner as to leave no doubt in the minds of their inspectors. Moreover, we believe that every specification should state clearly that work accepted by the inspector in direct charge should not be sub-

ject to rejection by a higher officer, unless it can be shown to have violated some *specific* requirement of the specifications. We say "specific," because there is a vast difference between the vague and vapory wording of a requirement like that above quoted for stone, and a requirement that is susceptible of but one interpretation. A "half-inch joint" is a specific requirement; a "workmanlike joint" is not. If a specific requirement is ignored by the inspector, his superior officer is justified in rejecting the work; but, if no specific requirement has been violated, then the superior officer is logically bound to indorse the inspector's acceptance. It is the only manly way, and it is the best way to insure the development of specifications that will be specific.

A contractor, who has done no small amount of Government work, recently remarked that he never knew where he stood from day to day, or from week to week. Unexpected rejections of work already accepted occurred so frequently as to wipe out his profits faster than they were made. He had given up doing Government work, because it was too risky.

Risk, in the class of work that he had been doing, arose not from uncertainty as to the character of excavation to be encountered, but from uncertainty as to the character of inspection to be encountered. It is indeed a pitiable condition of affairs when even a few contractors can give such reasons for fearing to bid upon engineering work; but what shall we say when the verdict, as applied to certain districts, approaches unanimity? There are unquestionably a large number of Government engineers who are no more arbitrary in their rulings than civilian engineers; but the stigma of risk has been branded upon the term "Government contract," and the just will have to suffer with the unjust in consequence.

In a way the word "unjust" is not the right word to use, for it implies moral obliquity, whereas there is less of morals than of judgment involved. It may, or it may not, be bad morals to refuse to abide by the acts of one's agents; it certainly is bad judgment, in the long run, not to do so. It may, or it may not, be bad morals to ask a man to name a definite price for an indefinite article, leading him to think that a garnet will be acceptable when in fact a ruby will scarcely be good enough—but, so long as one expects to remain in the market as a purchaser, such acts are the acts of folly.

In conclusion we may say that who shall select an inspector, or how he shall be selected, is of minor importance so long as specifications fail to tell him exactly what to accept and what to reject. Once an inspector is vested with authority to act as an agent, his superior officer should make it a practice to abide by the inspector's decision as relates to work already done. This seems like a harsh rule, for, under it, poor work must frequently be accepted; but it is not a whit harsher than the rule of common law, which makes a business man responsible for the acts of his agents. Where such a rule exists the acts of the agent are apt to be examined more frequently, and a greater care taken in selecting an agent. Finally, were the practice of abiding by an inspector's acts a practice more universally followed, engineers would quickly see the desirability of writing specific specifications.

LETTERS TO THE EDITOR.

What was a "Millwright's" Inch of Water?

Sir: The following is an extract from a deed dated some fifty years ago, relating to the diversion of water:

The right to divert from a certain stream through a Mill Race, water sufficient to vent an issue upon wheels of 2.787½ inches of water, as understood by Millwrights.

Can you or any of your readers give me any information as to the methods of measuring water by "Millwrights" at that time?

Very truly yours, F. H. Shaw.

Lancaster, Pa., March 24, 1905.

Destruction of Concrete by Alternate Freezing and Thawing Between Tide Levels.

Sir: The arbitrary disposition of this question by a correspondent in Engineering News of March 2, in which it is stated that: "in piers, abutments and dock walls between high and low water mark in ocean tidal waters, concrete surfaces are not proving satisfactory, etc," can hardly be accepted on this bare statement.

No doubt many cases have been found in which such is the result, but the composition and method of placing the concrete must be first known and considered before concrete as a whole can be condemned by such short and sweeping assertions as your correspondent makes.

The following quotation is from the annual address of the President of the Canadian Society of Civil Engineers in 1903, Dr. Martin Murphy, for many years Chief Engineer for the Province of Nova Scotia. At least, in his special district, where some experience has been had with tidal waters, the writer thinks Dr. Murphy's statements may be taken with more weight than any other engineer from that part of Canada:

There have been 320 highway bridges of metal superstructure resting on abutments and piers of concrete built in Nova Scotia within the last 18 years. Some of these have been in existence for a period of 15 years; some of them within the influence of the augmented and turbulent tides of the Bay of Fundy; most of them exposed to heavy drift ice, and all of them to the extremes of climatic exposure. Yet, but one failure can be recorded, and that is, no doubt, owing to careless workmanship. The introduction of concrete as a substitute for masonry above the surface in Nova Scotia, has been attended with such results that its employment is being extended and adopted for the renewal of masonry piers of railway bridges—piers that have been so abraded and displaced by clumps of moving ice, that renewal in the interests of safety became imperative. Yours truly,

A Maritime Reader.

Montreal, Can., March 6, 1905.

Notes of an Engineer in South Africa.

Sir: I have just completed a 3,200-mile trip in South Africa, visiting Natal Cape Colony, Transvaal, Orange River Colony and Portuguese East Africa.

The conditions in South Africa to-day are terrible. In Rhodesia there is actual starvation among the white people. Only the Rand (Johannesburg) is in any way picking up. The mines are working full capacity and the output of gold is great. There is little employment, though, for white labor. Kaffir labor and the 30,000 Chinese now here do most of the work. Thousands of young Englishmen and other white men are tramping the country, with no work, and no money. It is all laid to the war and change of government.

There is considerable railroad construction work going on in Natal, and some in the Transvaal, to give employment to the unemployed, and they have finally refused to allow more to be sent over the line.

In Orange River Colony there are under construction lines from Springfontein to Jagersport, Marcellas to a station beyond, Harrismith to Bethlehem and Ladysmith to Moddersport. Lines are being staked out from Moddersport to Bethlehem, Bethlehem to Kroonstadt, and Allwal North to Wepener. There is proposed the cross-line from Bloemfontein to Kimberley, which will probably be built later. Some work is planned in irrigation.

I visited the Victoria Falls of the Zambesi, and found the railroad track laid 25 miles north of the Falls and progressing to Kalomo. It will be extended to the copper fields, 300 miles north of the Falls, which will probably be the end of all construction for some years to come. The Cape to Cairo extension will probably be long delayed. The first work further to be done will be the line west across German West Africa, but you, perhaps, noticed lately that it was voted down by the German Reichstag. The bridge across the Zambesi at the Falls is a two-hinged arch 500 ft. c. to c., of skew backs. It was designed and is being erected by a French engineer, and the work is being done in England. But three panels at each end are now in place. They expect to have it bolted up in April, but am told they are now short of material. W. E. Crane.

Beira, P. E. Africa, Jan. 28, 1905.

A Question in Engineering Ethics.

Sir: Each profession has its own code of ethics. This code is based, presumably, upon certain standards of honesty, morality and courtesy. To the layman, these standards often seem quixotic, but occasionally they appear to be lamentably low. I ask for a little specific enlightenment concerning some things which an engineer may or may not do without dishonor to himself and to his profession.

If I employ an engineer to supervise construction, and pay him in full, until the contract between us is terminated, the wages agreed upon, is the knowledge of my affairs which he gained while in my pay in any sense a trust; or can he, without discredit to himself or to his profession, enter the employ of the contractor whom he was originally set to watch, and sell to this contractor, for use in a suit against me, copies of his records of my work?

The Constitution of the United States defines treason thus (italics are mine, of course):

Treason against the United States shall consist only in levying war against them, *or in adhering to their enemies, giving them aid and comfort.*

An army officer, discharged from the service, who sold to the enemy in time of war his knowledge of his nation's defenses would find no excusers. Is it possible that the engineering profession condones an act exactly parallel?

"Layman."

New York, March 25, 1905.

(Without knowing more of the specific circumstances of the case, it would be difficult to pass judgment upon it. Our correspondent is a little unfortunate in saying that he employed an engineer to *watch* the contractor. The engineer is or should be an impartial arbitrator between the employer and the contractor. It is his duty to supervise the construction to see that the contractor does what he agreed to do; but it is also his duty to measure the contractor's work fairly and impartially and see that the contractor gets credit for what he has honestly done. His records of the work should "provide things honest in the sight of all men," and the contractor has as much right to require the presentation of these records in court, in case of dispute as has the employer. It follows, therefore, that he has the right to subpoena the engineer as a witness and pay him the necessary fee as an expert.

He who buys the services of an engineer gains no right to any such service as the army officer renders to his country. The army officer serves with the motto "My country, right or wrong"; but the engineer who attempts to serve "his employer, right or wrong," acts contrary to what professional honor and honesty requires; and contrary to what a long list of court decisions have fixed as his duty.

On the other hand, of course, the engineer is bound to keep private such of his employer's affairs as are actually private; and any violation of such confidence by which his employer suffers damage is not only contrary to professional ethics, but is an act of which the courts may take cognizance.—Ed.)

The Capacity of a Cylindrical Grain Bin with Eccentric Conical Hopper.

Sir: Seeing the article in your issue of Mar. 9, entitled: "Determining the Capacity of a Cylindrical Grain Bin with Eccentric Conical Hopper," by B. F. Groat, one may well ask why so much mathematics to solve a very simple problem in mensuration? Referring to the figure on page 255 of that issue, we see that the total volume consists of a truncated cylinder plus an oblique cone with elliptical base. The volume of the first part is: area of circular base × perpendicular distance from center of gravity of the oblique section (its center to the plane of the base—in this case the axis. The obliquity of the base of the cone is known of course; hence the longer axis of the ellipse; its shorter axis is the diameter of the circle; the longest and shortest elements of the cone must be given in the design; hence the perpendicular distance of the apex to the elliptical base follows by the simplest trigonometry; hence $\pi ab \times \frac{1}{3}$ of this altitude is the conical volume. Simple addition gives the total.

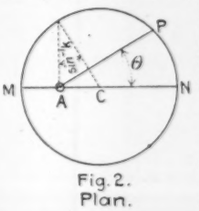
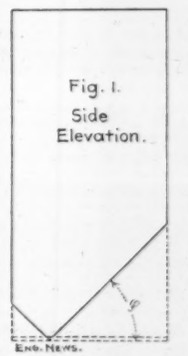


Fig. 2. Plan.



Plan and Elevation of Circular Grain Bin with Eccentric Hopper.

Yours truly,

Robert Fletcher.

Hanover, N. H., Mar. 11, 1905.

(Professor Fletcher's letter was submitted to Professor Groat, whose reply is appended.—Ed.)

Sir: Replying to Professor Fletcher's criticism of my method for determining the capacity of a cylindrical grain bin with eccentric conical hopper, appearing in your issue of Mar. 9, I will say:

The formula proposed by Professor Fletcher will not give the capacity of the bin, but will be in excess.

The problem is not a simple one in mensuration as Professor Fletcher thinks, though, with the aid of the formula and table published in the article under criticism, it admits of the simplest kind of solution—simpler than the solution of Professor Fletcher's formula, even if it were correct, because in the latter there would be several oblique lines to compute and several subsidiary geometrical problems to solve.

The volume does not consist of a "truncated cylinder plus an oblique cone with elliptical base." Therefore the

volume of the "first part" is not the "area of circular base × perpendicular distance from center of gravity of the oblique section (its center) to the plane of the base." Nor is the volume of the hopper ⅓ the product of its base and altitude.

Neither the "obliquity" of the base of the "cone" nor the longest and shortest elements of the conical hopper are known or required. In fact, the hopper is not a cone truncated by an oblique plane, but its volume is included by the plane of its mouth, a conical side of horizontal circular section and a parabolic ruled surface convex upward which separates the cylinder from the hopper. Whence it appears that the formula proposed by Professor Fletcher is in excess.

The method under criticism was devised to avoid "so much mathematics" and not, as intimated by the critic, to involve mathematics. It was devised in response to the request of an elevator engineer and contractor who understood the nature and difficulties of the problem and wanted a rigorous formula.

The person who uses the formula and table as they appear in my article will have nothing to do but substitute the five given dimensions (height and diameter of bin; eccentricity, slope and size of mouth of hopper) in the formula, thus obviating the necessity for any subsidiary problems, which is one of the principal advantages I claim for the method.

There are several approximate methods which admit of simple arithmetical solutions, but, as they are not exact and in reality involve more labor than the method I have offered, I do not advise their use.

It is only fair to state in conclusion that the method proposed by Professor Fletcher was not considered satisfactory by the engineer mentioned above, and this is what led to my investigation in the first place.

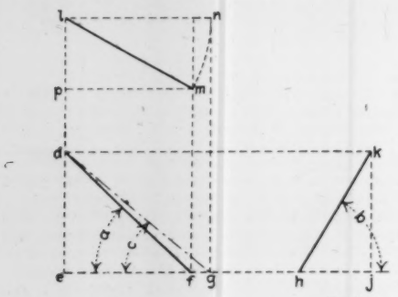
Yours truly,

B. F. Groat.

Minneapolis, Minn., Mar. 16, 1905.

The Corner Slope of Square Hoppers: A Table of Cotangent Squares.

Sir: In the design of bins and hoppers, especially weigh hoppers, it is well to make the angle at the corner greater than the angle of repose of the material therein, in order that the hopper may empty itself completely.



ENG. NEWS.

A table of natural cotangent squares will enable one to quickly determine the angle at the corner when the angles made by the two vertical projections of the intersecting hopper sides are known. This relation is derived, as shown in accompanying table.

In the sketch herewith let d f be the vertical projection of one hopper side and h k of the other. The line l m is the horizontal projection of the intersection of these two planes.

Then
$$ef = \frac{ed}{\tan a},\ hj = \frac{kj}{\tan b} = \frac{ed}{\tan b}$$
$$lm^2 = lp^2 + pm^2 = hj^2 + ef^2$$
and
$$lm = ln = eg$$
$$\therefore eg^2 = \frac{ed^2}{\tan^2 a} + \frac{ed^2}{\tan^2 b} \qquad (1)$$

The required slope of the corner is the angle c, and
$$\tan c = \frac{ed}{eg}$$
$$\therefore \tan^2 c = \frac{ed^2}{\frac{ed^2}{\tan^2 a} + \frac{ed^2}{\tan^2 b}} = \frac{1}{\frac{1}{\tan^2 a} + \frac{1}{\tan^2 b}}$$
and
$$\cot^2 c = \frac{1}{\tan^2 a} + \frac{1}{\tan^2 b} = \cot^2 a + \cot^2 b$$

Example: Let one hopper side form an angle of 50° with the horizontal, and the other side 48° with the horizontal plane. What is the angle at the corner? From the table, $\cot^2 50°$ is .7039 and $\cot^2 48°$ is .8100. Adding, we have .7039 + .8100 = 1.5139, and this number is the $\cot^2 39°$, the resultant angle.

To determine te length of edge dg, we have
$$dg^2 = eg^2 + ed^2.$$

From equation (1) this is,
$$dg^2 = ed^2 + \frac{ed^2}{\tan^2 a} + \frac{ed^2}{\tan^2 b}$$
$$= ed^2\ (1 + \text{cotan}^2 a + \text{cotan}^2 b.) \qquad (2)$$

In above example let height ed = 6 ft.
then $dg^2 = 36\ (1 + .1039 + .8100)$
$= 90.5004$
and dg = 9 ft. $6^{1}/_{16}$ ins.

It will be seen that formula (2) will be useful in the rapid computation of lengths of connection angles in corners of hoppers, lengths of hip rafters, etc., when above table of cotangent squares is used in conjunction with some table of squares of numbers in feet and inches.

Chas. T. Lewis,
Engineering Dept., Link Belt Machy. Co.

Chicago, Ill., March 11, 1905.

The Equipment for an Engineer Going to Panama.

Sir: Supplementing the very able letters of Mr. Harris in your issue of March 2, and Mr. Ackerman in March 16, in regard to the equipment of an engineer going to Panama, may I be permitted to make a few suggestions from my experience?

In the first place, no one at all inclined toward liver trouble or constipation should go to Panama at all, as these are the primary causes of the majority of fever cases.

In regard to foods, canned meats should be avoided as much as possible, avoid also ham and bacon, which will probably be always on hand in much profusion. If you eat meat once a day, as Mr. Ackerman suggests, eat very sparingly of it. Make the main articles of diet boiled rice, frijoles, fruits, etc., which is the native diet, and as all tropical travelers report, the best diet for the tropics.

Avoid coffee, if possible; if drunk at all, it should be very weak. Tea is a good beverage for the tropics, when it can be obtained, as it is refreshing, and harmless, but should never be drunk with lime, or lemon juice in it. Cocoa should be avoided altogether, or if this is impossible, at least drunk as weak as it can be obtained, as it has a very deleterious effect upon the liver.

There is one drink that is not only very palatable, but very healthful, and that is lime or lemon juice. Where you can obtain enough water that is not absolutely vile, to make a beaker of "limonada" you will find it both refreshing and beneficial, otherwise, if the juice is sucked directly from the lemon it is very good and will relieve the thirst.

Milk, both the "leche vaca" and the condensed variety, should be used very sparingly, if at all.

In general, it should be remembered that the constitution should be carefully watched, and no slight symptoms of disorder ever neglected, whether they be from stomach, bowels, or liver. You may be able to trust to a strong constitution to right any small ailments, while living in the United States, but down in the tropics these small ailments do not right themselves but give an opening for the fever to take hold.

It was remarked in Nicaragua, that a case of fever was invariably preceded by constipation. For this reason, the Commission served out salts, with orders that each member of the party should invariably take a dose before breakfast.

An example of the difference between this climate and that is had the first time the new comer happens to cut or scratch his hands or fingers. He will find that a scratch or cut that would ordinarily heal in two days in this climate will keep open indefinitely down there as a running sore.

From this example it will be readily unders... the organs of the body are just as slow in righ... all-ments in the tropics, as the blood is in pu... itself and healing up abrasions.

The fevers are directly caused by ailments ... liver, but these are often superinduced by neglect ... com-ach or bowels.

In regard to the clothing that Mr. Harris ... ts to be taken, it was the experience in Nicara... the clothing that was not in daily use would ge... and spoil, especially linen shirts, collars or cuffs.

I would suggest to a man who intends to ... the field to travel as light as possible, and to ... his working clothes, three pairs of duck trousers, ... heavy "Army" blue or gray flannel shirts, Stetson ... ero, three pairs of heavy shoes, six pairs of light wo... woolen stockings, and two pairs of leather "Puttee ... ings. This may be supplemented by one light weight ... erge suit to wear on the steamer going down, a... town while there, one Fedora, or straw hat, three ... com outing shirts, one-half dozen turn-down collars ... pair light weight russet or black calf skin shoes, ... suits of lightweight woolen underclothing, one camp ... bag.

To one who expects to be in town most of the ... the three pair of duck trousers should be replaced by ... khaki or linen suits, the three pair of heavy shoes, by ... pair of light shoes, and the three heavy flannel shirts ... three outing shirts, and the kit bag by an ordinary ... bag or suit case.

In addition to these articles, three pairs of flannel pajamas should be carried by all tropical travelers, and a pair of straw slippers will be found very useful to avoid "jiggers." The few simple drugs mentioned by Mr. Harris do not take up much room, and would be found very convenient.

In my opinion, anything else in the way of impedimenta would not only be found superfluous, but very much in the way.

Be careful to shake out all clothing and shoes before pulling them on, to avoid scorpions and tarantulas, and avoid walking across the floor in your bare feet, on account of jiggers. These may be got rid of by picking out with a penknife and pouring kerosene in the wound to kill the eggs.

Respectfully submitted.

Jno. Stockton, C. E.

1221 Washington St., Hoboken, N. J., March 21, 1905.

Moments in Columns Due to Eccentric Loading.

Sir: Herewith is an analysis of the effect of eccentric loads on columns under four different sets of conditions of a column with reference to the method of supporting or fixing of ends.

Case I.—Column fixed at base with top free to move laterally, as in Fig. 1, loaded with a load W at distance a from the center line of column. Under the usual methods of supporting the eccentric loads we can imagine the bracket to assume the shape shown so far as the lines of stress are concerned. By a resolution of forces we find that the load W may be replaced by a central load W and a horizontal couple B such that B y = W a. The central vertical force produces no bending moment except as the column actually deflects and in the following this moment is neglected. Neglecting the vertical load the column is equivalent to a cantilever beam acted upon by a couple; the bending moment is found to be W a and is uniform from the base of column to bottom of bracket.

Case 2.—Column with both ends simply supported, loaded as in Fig. 2. By reasoning similar to Case 1, we have the case of a beam supported at each end and loaded with a central load and with a couple such that B y = W a. The end reactions are found to be W a ÷ l and the bending moment at any point distant x from the end = W a x ÷ l. This moment is a maximum at the top or bottom of the bracket and if the bracket is in the center of the column and the depth of bracket y is small it becomes nearly W a ÷ 2. If the bracket is at the end of the column the bending moment is a maximum and equals (nearly) W a.

Case 3.—Column fixed at one end and supported at the other, and loaded as in Fig. 3. This assumes the condition of a beam supported at one end and fixed at the other and loaded with a couple. From the principles of continuous beams we find the reaction at the supported end = $R = \frac{B}{2}\ (3\ k_1 - 3\ k + k^3 - k_1^3)$ and the bending moment at distance x from the supported end = R x for $x < k$ l, and R x − W a for $x > k_1$ l. If the distance y is small the bending moment = W a ÷ 2 (nearly) when the bracket is half way between the point of contraflexure and the supported end and W a (nearly) when it is at the supported end, which is the condition of maximum moment.

Case 4.—Column fixed at both ends and loaded as shown in Fig. 4. This assumes the condition of a beam fixed at both ends and loaded with a couple. The reaction at the base =
$$R = B\ (3\ k_1^2 - 3\ k^2 + 2\ k^3 - 2\ k_1^3).$$
The bending moment at the base =
$$M = -\ B\ L\ (k - 2\ k^2 + k^3 - k_1 + 2\ k_1^2 - k_1^3)$$
The bending moment at distance x from base = R x + M

SQUARES OF NATURAL COTANGENTS.—C. T. LEWIS.

Angle.	Cot.²	Angle.	Cot.²	Angle.	Cot.²	Angle.	Cot.²	Angle.	Cot.²
1°	3,282.144	19	8.41	37	1.76	55	.4900	73	.0936
2	820.249	20	7.56	38	1.64	56	.4542	74	.0817
3	364.046	21	6.76	39	1.51	57	.4212	75	.0718
4	204.490	22	6.10	40	1.41	58	.3906	76	.0620
5	130.645	23	5.52	41	1.32	59	.3612	77	.0533
6	90.440	24	5.06	42	1.23	60	.3329	78	.0449
7	66.259	25	4.57	43	1.14	61	.3069	79	.0376
8	50.600	26	4.20	44	1.06	62	.2830	80	.0309
9	39.810	27	3.84	45	1.000	63	.2590	81	.0249
10	32.140	28	3.53	46	.9312	64	.2371	82	.0196
11	26.410	29	3.24	47	.8686	65	.2171	83	.0148
12	22.000	30	2.99	48	.8100	66	.1980	84	.0110
13	18.750	31	2.75	49	.7551	67	.1797	85	.00765
14	16.080	32	2.56	50	.7039	68	.1632	86	.00488
15	13.910	33	2.37	51	.6544	69	.1474	87	.00274
16	12.110	34	2.19	52	.6099	70	.1324	88	.001218
17	10.69	35	2.04	53	.5670	71	.1183	89	.000302
18	9.48	36	1.87	54	.5270	72	.1056	90	.0000

for x < k l, and R x + M — W a for x > k_1 l. When the distance y is small the bending moment is nearly $\frac{W a}{2}$

when the bracket is half way between the points of contraflexure and approaches W a as the bracket approaches one of the points of contraflexure, which is the condition of maximum moment.

The method usually employed by engineers in figuring the bending moment on columns is to assume that it equals the product of the load by its eccentricity, or W a, while cause it has been impossible to trace infection to sewer gas. In support of his argument Mr. Hazen uses the old and familiar illustration that sewer cleaners and laborers on disposal works are free from infection. Without in the least disputing the findings of the scientists, the writer is of the opinion that no deduction should be drawn from the effect or non-effect of the air from diluted sewage dissipated into the fresh air at disposal works on the lungs of men generally immune thereto, as to the effect of foul sewer air, eminating from stagnant and putrifying sewage, in poorly designed and poorly constructed

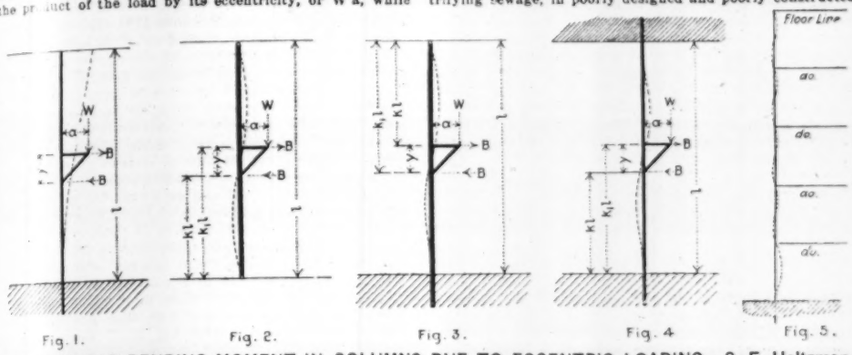


Fig. 1. Fig. 2. Fig. 3. Fig. 4 Fig. 5.

DIAGRAMS FOR BENDING MOMENT IN COLUMNS DUE TO ECCENTRIC LOADING.—S. F. Holtzman.

from the above analysis it appears that this amount of bending moment obtains in a very few cases and that in the great majority of cases the actual bending moment is approximately half this amount. For example, take the case of the usual shop building with a crane track supported by brackets on the main roof columns. This is similar to Case 3, with the load applied some where near half way between the point of contraflexure and the supported end. The resulting bending moment is about ½ W a instead of W a, as usually assumed.

Fig. 5 represents approximately the way a wall column in a steel cage office building would bend if loaded with heavy eccentric wall loads on the outside of the columns. The beam connections to the column will be strong enough to hold it in line at each floor level and the effect of each eccentric load is felt only by the section of the column at that floor level. The series of eccentric loads has the effect of fixing each column section with reference to the section above and below it. If the story heights are equal we have for each story, except the top and bottom story, the condition of a column loaded in the middle of its length with the ends fixed, which gives a bending moment equal to ½ W a. The special conditions at top and bottom may be figured by the formulas given.

As a general proposition it will be safe to assume that the eccentric load produces a moment = ½ W a, and allow the factor of safety to take care of the stress produced in excess of this amount.

Very truly, S. F. Holtzman.

Room 87, Treasury Bldg., Washington, D. C., March 6, 1905.

Ventilating Sewers Through House Soil Pipes.

Sir: In relation to the omission of the trap at the wall of the house, it seems to me that it is not enough of a novelty to cause any great shock to sanitarians to-day. I would say that in this city there is no trap at the wall on any building connected with the sewer. This system has been in use for eleven years. While it may have no particular significance, it may be interesting to state that the death rate in this city for the last census year, and also for the last year as reported by the State Board of Health, was the lowest of the 23 cities in Massachusetts having over 25,000 population. The recommendation to adopt this system was made in 1893, and I have never yet heard any complaint as to its practical working.

Respectfully yours, Chas. R. Felton,
City Engineer.

Brockton, Mass., March 13, 1905.

(We commend this testimony to the attention of the towns and cities which still compel, by municipal ordinance, the use of disconnecting traps, and impose divers pains and penalties for its omission.—Ed.)

Sir: I have read with interest the extract from Mr. Allen Hazen's report on the Winnipeg sewer ventilation; also your editorial comment thereon. To those of us who have for years been constant in season and out of season in advocating the omission of the house trap, it is a pleasure to have this added testimony. We should, however, in advocating such changes be careful not to let the pendulum swing to the other extreme and create the feeling that there is no need to properly safeguard all plumbing fixtures.

Mr. Hazen, backed by many eminent bacteriologists and physiologists, states that infection cannot be propagated by sewer gas. This conclusion is reached largely because it has been impossible to trace infection to sewer gas. In support of his argument Mr. Hazen uses the old and familiar illustration that sewer cleaners and laborers on disposal works are free from infection. Without in the least disputing the findings of the scientists, the writer is of the opinion that no deduction should be drawn from the effect or non-effect of the air from diluted sewage dissipated into the fresh air at disposal works on the lungs of men generally immune thereto, as to the effect of foul sewer air, eminating from stagnant and putrifying sewage, in poorly designed and poorly constructed sewers, and passing there from into the unventilated or imperfectly ventilated rooms of dwellings occupied by those less able to throw off the ill-effects of this polluted air.

It is generally supposed that water is the usual medium for the transmission of infection in typhoid fewer and therefore typhoid fever germs should be found in water subject to such influences, but how very seldom, if ever, have typhoid fever germs been found in the large number of examinations of the water of the Schuylkill River at Philadelphia, when it was definitely known that the excreta from typhoid fever patients was being discharged through the sewers into the river above the point where the examinations were made.

A reason for the abandonment of the house trap just as vital as that of securing ventilation for the sewers is that implicit dependence was placed upon the effective operation of the traps in excluding sewer gas from the houses, when in reality, either by syphonage or evaporation, the trap often fails to perform the purpose for which it was intended.

While advocating the omission of the house trap it becomes the more important to demand properly trapped fixtures throughout the house. The writer cannot believe that sewers designed and constructed so poorly that they are nothing better than elongated cesspools are transformed into harmless water courses simply by the omission of the house traps. This was the impression, right or wrong, which the writer received from a careful reading of Mr. Hazen's report on Winnipeg sewers.

Yours truly, Alexander Potter.

143 Liberty St., New York City, March 20, 1905.

Sir: In a rather belated reading of your issue of March 9, I find Mr. Allen Hazen's report on the sewers of Winnipeg commented upon as "especially noteworthy," because Mr. Hazen recommends that these sewers "be ventilated through the house soil-pipes, a proposal which, even at this day, will doubtless shock some who pose as sanitary experts."

Sewers have been ventilated through soil-pipes so generally and for so long a time that it seems incredible that any one should be surprised—much less shocked—by the recommendation. In "How to Drain a House," written in 1884, Colonel Waring said:

The question of a main trap between the house and a public sewer has been much discussed, and is still determined by no rule. * * * I am inclined to the belief that there should not be such a trap in the case of discharge into a sewer, unless it be especially foul.

In 1887, the Borough of Stamford, Connecticut, adopted an Ordinance Regulating the Use of Sewers, which contained the following provisions:

All pipes from the sewer connection to the top of the soil-pipe must be fully four (4) inches in interior diameter at every point.

No trap or any manner of obstruction to the free flow of air through the whole course of the drain and soil-pipe will be allowed; and any mechanic who shall directly or indirectly place, make, cause, or allow to be placed or made any trap, contraction or other obstacle anywhere in the course of such drain or soil-pipe, shall, in addition to the penalty herein prescribed, forfeit his license," etc.

In "Sewerage and Land Drainage," published in 1889, Colonel Waring said:

I am, myself, decidedly of the opinion that, while there may be some doubt as to the policy of omitting the trap in a few exceptional cases, * * * I know of no case where, with even tolerably good sewers, all valid argument is not entirely in favor of the universal omission of traps. There is no way in which sewers may be so efficiently and inoffensively ventilated as through house drains; if properly constructed, there is not the slightest objection to this use being made of them, and there is little if any question that wherever the usual trap is used, the decomposition of the deposit that it will inevitably cause will produce a fouler air in the pipe than it would receive from the sewer."

In 1890, when called in consultation by the city authorities of Columbus, Colonel Waring said:

Ventilate the house drains from the sewer through to the top of the roof. I should never put, or allow to be put, a trap on the main drain.

The 1891 report of the State Board of Health of New Hampshire, in describing the sewerage of Keene and Laconia, said:

The ventilators of the whole system are the house drains and soil-pipes of all the houses connected, there being no trap between the sewer and the open mouth of the soil-pipe above the houses.

When sewers were "elongated cesspools," running traps were an obvious necessity; but I have long considered their advocacy as one of the clinging burrs indicative of practice when sanitary engineering was little more than a trail through the woods.

G. Everett Hill.

156 Fifth Ave., New York City, March 24, 1905.

The Employment of Inspectors for Public Work.

Sir: In the construction of public works it can be taken for granted that inspectors will be employed. It is important to know how the best results can be secured in the appointment of inspectors. Civil service rules govern but a small percentage of public work. It is often customary for the inspectors to be the direct appointees of the engineer in charge of the work, either because the engineer's contract requires him to furnish the inspectors, or because the engineer has been able to have the appointment of inspectors placed absolutely in his hands. Most engineers consider the latter condition as ideal. Perhaps it is. It usually occurs under either of the conditions mentioned above, that young college men, either graduates fresh from some college or technical school, or undergraduates, seeking experience fill the inspectors' positions.

While there is much to commend this practice and the appointment of young college men, there is something to be said on the other side. These young men, with some knowledge of theory, often make the securing of experience for themselves or the testing of some theoretical teaching a paramount thing, frequently to the unjust financial detriment of the contractor, by unreasonably insisting upon compliance with their own interpretations of certain requirements of the specifications and contract.

This would be particularly the case where the inspector is made to outrank the chief engineer in decisions on certain features of the work, as is undoubtedly the case in a contract for some government work soon to be let. The contract in this instance reads:

Where the word "engineer" is used it shall be and is mutually understood to refer to the chief engineer of the ———— Service, or any of his authorized assistants or inspectors, limited by the particular duties entrusted to them.

The contract further says:

The decision of the engineer (previously defined in the specifications to refer to the inspectors on certain portion of the work) shall be binding on both parties.

The contract does not name or define the duties of the various assistants or inspectors, therefore the contractor in undertaking this contract places himself at the tender mercies of many unknown and untried men. If he bids intelligently, therefore, he must add a large percentage to cover the chances he takes of having unknown men as final arbiters upon his work.

Although digressing somewhat from the main subject, perhaps, it is my opinion that the engineer referred to in any contract should be one man, preferably mentioned by name, making due provision for his death or disability. This one man should be the final arbiter, as in all jurisdictions there are lower courts and a court of last resort. To allow the man directly in charge of any portion of a large contract to be the final arbiter is often to work prejudice and hardship upon the contractor, as the man in charge has not always had sufficient experience or is perhaps too prejudiced to judge justly.

To return to the main discussion concerning inspectors, the aim of the engineer in charge should be to get the highest possible results out of the conditions usually surrounding the appointment of inspectors on public work.

To make a good inspector a man need not necessarily have had previous experience as an inspector. Any bright, active, intelligent and honest man, endowed with "horse sense," can make a good inspector, provided his avoirdupois and his health do not preclude the possibility of his quick access, ascent or descent, to all portions of the work under construction.

On much public work the engineers do not name the inspectors, and it might as well be admitted frankly that in the majority of cases the securing of such appointments is directly due to political influence or obligations owed directly or indirectly, and, so long as the political applicant is worthy and fit for the position he secures, no harm can come to the state or city by such appointments. The person from whom the appointment is sought has

done his whole political duty towards the applicant when he secures for him the position. If his retention is made to depend entirely upon his ability faithfully to discharge the duties of his office, this method of appointment is as good as can be devised, and is of advantage to the engineer as well as to the city or corporation retaining the engineer's services, because in most cases there is a closer personal contact between the inspectors thus appointed and the municipal officers and the community in general than there is between the engineer and the same officers, which, to the engineer trying to do his whole duty well, can only result beneficially in giving confidence to the community in his work.

The placing of the responsibility for the appointment of proper men as inspectors outside of the duties of the chief engineer gives balance to the conditions surrounding the work of construction that is not objectionable. The participation in appointments of inspectors on public works by municipal officials, if limited simply to the securing of appointments and not to the retention in office of unworthy men, is not an evil. On the other hand, the concentration of the power of appointment of both assistant engineers and inspectors in the hands of the chief engineer is not always for the best interests of the work. The engineer, whoever he may be, is not so infallible that certain checks are not often very salutary.

In a construction such as the Joint Outlet Sewer for a number of New Jersey towns, recently constructed under the supervision of the writer, where many municipalities contributed directly to its construction, the appointment as inspectors of reputable citizens from the various municipalities created a feeling of confidence that would not have existed had the appointment of inspectors been vested in the hands of the engineer alone, and this condition was of positive advantage to him.

In this case the Commissioners responsible for the appointment of inspectors stood by the engineer when he discharged in some cases peremptorily, such inspectors as proved themselves unfit. While the withholding of the power of appointing inspectors from the engineer is not a serious drawback, but perhaps an advantage, the withholding from him of full power to discharge inspectors would be a serious detriment to the securing of good construction, and would indeed be a vital error. The appointment of inspectors by a commission, or other body, need not relieve the engineer from the responsibilities assumed by him under his contract, but should he be compelled to retain men in whom he has no confidence the case would be different, and the responsibility laid upon him would certainly be released. The engineer must therefore be vested with full power of discharge, if the interests of the work are to be conserved.

Every inspector employed on the construction of the Joint Trunk Sewer above referred to was a political appointee, and the results secured on this work would indicate that this method of choosing inspectors was not wrong. Each inspector, immediately upon his appointment, was placed absolutely under the control and direction of the engineer, who had full power of discharge, and in every case where the engineer exercised this power he was unanimously upheld and endorsed in his action by the Commission, even when his action, in one case, operated for the discharge of an inspector who had been a former member of the Commission itself.

I might add in closing that this discussion has nothing whatever to do with professional engineering inspectors upon shop work, etc., but refers to an entirely different line of inspection.

Alexander Potter,
Consulting Engineer.

143 Liberty St., New York, Feb. 27, 1905.

What Is the Stress in the Wires of a Wire Rope Due to Bending?

Sir: In Engineering News of Feb. 9, 1905 (p. 149), is a criticism of the writer's paper on "Bending Stresses in Wire Ropes" read before the Engineers' Society of Western Pennsylvania, which winds up thus:

> The conclusion arrived at in Mr. Diescher's investigation, that there is a compensating action in the wires whereby the bending of a wire rope takes place without severe stress in any part of the strand, owing to the tendency to pull in the upper part being equal that to shove in the lower part, is not borne out by practical results.

Referring to the foregoing statement, I wish to say, that in my experience in connection with inclined planes I had many occasions to specify wire ropes of the quality designated in the manufacturer's lists as "Crucible Steel Ropes" and in this connection I learned from numerous tests made that the wire used in making these ropes has only in rare instances an elongation of more than 2% in 12-in. specimens when ruptured under ultimate strain. I know also from experience, in cases where an elongation of 4% in 12 ins. was specified, and the tests showed only an average of 2%, with a maximum of 2½%, owing to which the wires had to be rejected, that reputable manufacturers gave up the contract, because, as they said, "wire that pulls from 160,000 to 180,000 lbs. per sq. in. and stretches 4% in 12 ins. at ultimate load, cannot be produced."

The fact is that unless the maker of the rope knows that every coil of wire to be used in a rope ordered will be tested, and rejected if not up to the stipulated elongation, which is rarely over 4% = 0.48 ins. in 12 ins., then that elongation will not be over 2%. It may safely be said that of every 100 ropes bought, 99 are taken on the strength of the assurances of the sales agent.

The outer circumference of a 2-in. diameter rope wound around a sheave of any diameter is 6 ins. longer than that of the center line of the same rope, and the inner circumference is 6 ins. shorter. And to the extent of these dimensions must the elongation in the upper wires and the contraction in the lower wires take place in order that such a rope may be bent once around a sheave of no matter what diameter. Hence, assuming that the adjustment is done by elongation, and compression of the wires, as a matter of course both these changes ought to take place within the limit of elasticity. But how shall this be accomplished if the elongation at rupture is only 2%, or 6 ins. in 25 ft., being the circumference of the middle circle of a 2-in. diameter rope around an 8 ft. diameter sheave? And since elongation and compression per coil are constant, what would happen if the diameter of the sheave were only 4 ft. instead of 8 ft.?

There are inclined planes which have been engaged over 30 years in the transportation of passengers, on grades up to 72%, on which a rope sometimes travels as much as 50,000 miles in the course of its life, and in that time every point in it is bent about 41,000 times and as often straightened. How is it to be accounted for that wire can be strained 41,000 times to the point at which it would snap if so treated in the testing machine, and notwithstanding this fact, when after all that abuse the rope is discarded it still holds together? Does this not prove conclusively that the stresses that tend to cause elongation and compression of the strands on the opposite sides of a bent rope are rendered ineffective by mutual compensation, and that said strands are not subjected to actual elongation and compression, and, therefore, the bending strains are small compared with the load strains?

Some time ago the writer was requested to examine a report made by another engineer, on certain details on an inclined plane, that have an essential bearing upon the safety of passengers and teams in transport. As may be expected, a considerable part of that report related to the ropes, and referring to them it said that, "taking into account load and bending stresses, after the ropes reached a certain stage of deterioration in service, the factor of safety based upon the elasticity of the wires is 1.51." This somewhat startled the owners of the plane, who, in order to get satisfactory information on that point, wrote to the firm that furnished the ropes, one of the foremost manufacturers of wire rope in this country, and, responding, the head of that firm said: "For good results the bending strain added to the direct tension due to the load, should be within the elastic limit of the wires." This remarkable opinion seems to be based upon experience, and suggests the inference that according to records on hand, as long as ropes were not strained beyond the elastic limit of their wires, they were safe. The elastic limit can be ascertained by the testing machine to a satisfactory degree of exactness, and the strain due to the load can be found quickly by calculation, hence an overrating of these two amounts is not likely to occur, but how about the bending stress; this latter is not so readily ascertained? If experience shows that a rope is safe if the bending stress, calculated by the formula in Kent's book, plus the load stress come within the elastic limit of the wires, it signifies that the bending stress thus found is far in excess of the real amount, and that in this way a wide margin of safety is unknowingly provided, which leads to the misinterpretation of the actual conditions. What engineer would dare to use a rope to the edge of the elastic limit of its material when in doing so he jeopardizes scores of human lives?

Samuel Diescher.

Farmers Bank Bldg., Pittsburg, Pa., Feb. 24, 1905.

Sir: Many thousands of dollars are spent annually for wire rope in this country and millions of people, at some time or other, have their lives dependent on the strength of a wire rope. Wire rope has been used for many years and some companies make a specialty of manufacturing it, sometimes almost to the extent of making it and nothing else. And yet with all these conditions so favorable, seemingly, for a thorough knowledge of the strength of wire rope, it now becomes evident that one of the "authorities" or rather the best authority in America on the subject of the strength of rope as it is actually used, i. e., over sheaves, is a misleading authority.

Mr. Hewitt's reply to the criticism of Mr. Diescher, published in your issue of Feb. 9, 1905, ends with the statement that he (Mr. Hewitt) is "satisfied" that the formula given in Kent is "correct and reliable," and this satisfied feeling he bases upon his "many years' experience." That is to say, Mr. Hewitt even after his attention is called to it is unable to see any error in his theoretical (and theoretical only) rules for the strength of a wire rope under the conditions actually obtaining in practice, i. e., bending over a sheave.

This illustrates how little reliance is to be placed on long-standing authority as well as the vast amount of inertia that exists in the engineering world. Mr. Hewitt's rules are *not* correct. Cases can be shown where they are in error. Mr. Diescher's criticism is just and correct. And yet Mr. Hewitt's rules have stood unchallenged [illegible] years.

This is no attack on Mr. Hewitt personally [illegible] his motives. He deserves the thanks of the engineering [illegible] this country for having been the first to study [illegible] after and to put forward a rule which though incorrect [illegible] on the side of safety. But is there not here a [illegible] that may be raised in the minds of engineers as to [illegible] other many another long-accepted rule may not be [illegible] or if this one is? Does it not show the engineers of [illegible] un try to be too careless, too *lazy*, if they let such [illegible] go unchallenged for so long? Surely it is important [illegible] know whether all the practical work done so far with [illegible] in this country has been without any regard to [illegible] the word is understood in bridge building, structural [illegible] work and similar work? If all wire rope, or [illegible] of it has been bought at a guess as to how large a [illegible] certain work calls for, then is it not now, if it [illegible] was before, time to begin to learn some things [illegible] and practically about the bending stresses in wire [illegible] ropes.

I know of my own knowledge of a place where [illegible] after rope has been worn out and each rope has given [illegible] months and some of them years of service and never a [illegible] has broken where the conditions were as follows: Size of the rope 1¼ ins.; material, cast steel; load on the rope [illegible] lbs., i. e., the stress was this amount, without [illegible] the bending stress; size of the sheave over which this rope bends, 7 ft. diameter. Now, by the tables which Mr. Hewitt gives in his book on "Wire Rope and Its Application to the Transmission of Power, etc.," published by the Trenton Iron Co., in which the bending stress is clearly stated and in the best form that I know of, the maximum safe stress of such a rope made of "cast steel," which is the quality of rope that was used in the place I refer to, is given as 33,333 lbs., the factor of safety of three (3) being used (see page 8 of the pamphlet referred to). But from this 33,333 lbs. there is to be deducted the stress due to bending and that by the table on page 20 of the same pamphlet is 16,153 lbs., so that one would think from consulting this pamphlet that 33,333 minus 16,153 or 17,180 lbs. is the limit of load for such a rope under such conditions.

But in actual practice day after day and year after year, which is the very best proof of what a rope will do, one rope after another stood 23,000 lbs. And the rope when worn out showed no breaks in the outside wires. It did *not* have the appearance of the rope shown in Fig. 207, page 17, of the pamphlet already referred to. This rope was besides often subjected to tremendous jerks.

In the "Coal and Metal Miners' Pocketbook," p. 125, is a diagram that is very clear, easy to consult, but entirely wrong as tested by this particular instance. If the figures given at the bottom of the diagram, i. e., the lower row of figures, are the diameters of the drum or sheave in feet (as they seem to be) then the limit of load for the rope under the conditions given above can be easily read off the diagram as only 13,500 lbs. It may be said that these figures as well as those of Mr. Hewitt's err on the safe side, if they are in error at all, and therefore should not be called in question. But why should one part of a design have a factor of safety that puts it on "the ragged edge" and another part of the same design have a factor of safety that makes it really almost unbreakable, or rather why should one part be made excessively strong and another part that is of the same material be made just barely strong enough to do? Steel in one place, steel in the other place, both subject to the same jerks, both to the same stress, transmitted from one to the other, and yet one is made as light as possible the other has strength in excess.

But the main point that comes up and is suggested by Mr. Diescher's criticism is this: How much are we blundering along in the dark accepting tables on the prestige of the authors of those tables assuming that because those authors are well-paid, well-educated, well-placed, not-to-be-questioned men, men who have high status in the profession, that therefore all they have published is reliable? And there is this other question: how far should we let such matters be a personal matter and refrain from any criticism for fear of giving offence to the man's "amour propre" by calling in question something he has given out as correct and feels inclined to stick to just on the grounds that "it is right because I said it" and I do not intend to change my mind?

This questioning of Mr. Hewitt's rules is, too, a personal matter in another sense in that Mr. Hewitt's company, the Trenton Iron Co., furnished most of the ropes that were worn out—after long and satisfactory service—in the place referred to above.

I hope this communication will call others out and that we may hear from a number of men who know of cases where elevator ropes and other wire ropes have been subjected to known loads in excess of the loads indicated by the theory of bending stress worked out by Mr. Hewitt and quoted by Mr. Kent.

Let us all believe the motto of Oxford University: "Magna est Veritas et prevalabit"—truth is mighty and will prevail, in the human way at least that we need it in engineering, approximate truth, *useful* truth.

Yours truly,

Nashville, Tenn., March 4, 1905.

(Proof of the above letters were furnished to

Mr. Hewitt, and we append his reply as follows.—Ed.)

I have your favor of the 10th with proofs of the letters referred to, written in reply to my letter to you of Jan. 25, published in Engineering News of Feb. 9, which was a reply to your former communication calling my attention to the paper on "Bending Stresses in Wire Ropes," recently read before the Engineers' Society of Western Pennsylvania by Mr. Samuel Diescher. If I had had any idea that my reply was to be published, I would have written more at length, but at the time I happened to be very busy, and wrote more hastily perhaps than I should have done, in view of the fact that Mr. Diescher's paper, as you point out, raises the question of the correctness of my formula for determining the bending stress in a wire rope, as published on page 18 in the book of The Trenton Iron Co., entitled "Wire Rope and Its Application to the Transmission of Power," and in Kent's "Mechanical Engineer's Pocket Book," page 918.

If you will take the trouble to compare this formula with that of Julius Weisbach (see "Mechanics of Engineering," Vol. 3, translated by Gustav Herrmann, page 288), the formula of F. Reuleaux (see "The Constructor," translation of H. H. Suplee, page 197), and that of W. J. M. Rankine (see "Machinery and Millwork," page 533), you will see that my formula corresponds closely with the formulas of these eminent authorities. It differs from them in the fact that I have introduced factors by which allowance is made for the average distance of the wire from the surface of the drum, and also an allowance for excess in length of wire, due to the compound spiral form, over length of corresponding portion of rope, which was pointed out by Mr. H. C. Newcomer in an article on "Rules for Working Loads of Wire Elevator Ropes," published in Engineering News, Jan. 15, 1903. This brings into my formula a constant that does not appear in the formulas of the authorities mentioned, and gives somewhat lower bending stresses, but the difference is only appreciable where the diameter of the rope is large as compared to the diameter of the sheave. I would also call attention to the formula of Mr. E. T. Sederholm, former Chief Engineer of Fraser & Chalmers, to be found in the Allis-Chalmers' Catalogue No. 2, "Hoisting Engines," page 109; also to Mr. Newcomer's formula in the article referred to, both of which are in accord with those of Weisbach, Reuleaux, and Rankine.

Referring to the chapter on Rope Transmission in "The Constructor," under the caption "Influence of Pulley Diameter," page 197, Mr. Reuleaux gives tables showing the relative stresses due to the tension or driving force, and to bending for various ratios of rope and sheave diameters for iron-wire rope, and puts in full-faced figures those corresponding with the most advantageous ratio, that is, when the radius of the sheave is 833 times the diameter of the individual wires of the rope or a ratio of sheave diameter to wire diameter of 1666, and makes the following comment: "Even in this advantageous proportion the stress due to the bending of the wire around the pulley is double that due to the tension of the driving force. According to my calculations, the most advantageous ratio of sheave diameter to wire diameter is for iron ropes about 1440, and for steel ropes about 712, or about one-half of that for iron." Mr. Rankine, in "Machinery and Millwork," page 448, says: "In order that the rope may not be overstrained by bending of the wires of which it consists, in passing around the driving and following pulleys, the diameter of those pulleys should not be less than 140 times the diameter of the rope, and is sometimes as much as 260 times." This applies to iron rope, as at the time it was written iron ropes were used exclusively for transmitting power.

Comparing this with my figures on page 25 of the Trenton Iron Co.'s book, it will be seen that the minimum figure is something less than my figure for 7-wire iron rope. In all other cases my figures are less, indicating that smaller sheaves may be used, especially in the case of steel rope, and recent practice corroborates the correctness of these figures, steel ropes having now almost entirely superseded iron ropes for transmitting power.

Mr. Diescher, in his paper referred to, says that: "According to a rule long since adopted in practice, sheave diameters shall equal, or exceed, 48 diameters of the corresponding ropes." I presume that he refers to steel ropes of 19 wire strands. My figure is 47.2, which corresponds very closely with the above rule.

It will thus be noted that I am not the first to have studied the effect of bending in wire ropes, and never claimed to be. I have simply developed the formulas of the older authorities, and presented the matter in a shape more convenient for use, in the hope that users of wire rope would clearly understand this matter, and realize the importance of considering the bending stresses, and thus avoid the too common mistake of using sheaves too small for the purpose. Many instances have come under my observation of ropes with wires broken at the crown faces as shown in the accompanying illustration (from photograph), from undue bending and showing little or no surface wear. I have also had occasion to observe in a few instances cases where breaks have occurred at the points where the wires of one strand cross those of another, but could not trace the cause of this to undue bending. Breaks rarely occur within the rope in any case. If there is the compensating action in the wires such as Mr. Diescher says takes place when a wire rope is bent, it does not seem likely that a rope would break up in this way.

If Mr. Diescher's theory is correct the actual bending stress in a wire rope is very much less than my formula gives, and all of the authorities that I have referred to are wrong, and we will have to turn over a new leaf on this subject, but it seems to me that before setting aside these authorities it would be well to obtain results based on something more reliable than a speculative theory, backed up by a few citations of instances in practice that apparently confirm it. It is usually not a

difficult matter to find exceptions to any rule, or to cite instances that apparently disprove a formula, but where one such case is cited, hundreds of others might be found to prove its correctness, and it very often happens with such citations that if all the conditions could be known they would in reality substantiate the correctness of the formula. In the book issued by The Trenton Iron Co., the maximum safe stress is taken at one-third of the ultimate stress and the safe load is considered as the difference between this and the bending stress. I am well aware that ropes have been worked under conditions where, making allowance for the bending stress as given in my tables, the total stress would be much greater than one-third of the ultimate stress, and with good results. The limit of elasticity of the wires in any wire rope is above one-third of the ultimate stress. In the best of iron wire rope as now made, it is about one-half of the ultimate stress. In steel ropes the limit of elasticity is much higher and is not so well defined; in fact, with the higher grades of steel wire as used in plow steel ropes it approximates the ultimate stress. Frequently in my calculations I have taken the maximum safe stress at two-fifths of the ultimate, and in some instances, as in case of derricks where small sheaves are absolutely necessary, I have taken it at one-half, since no one expects a wire rope to last as long on a derrick as on an inclined plane. For most purposes, however, especially where the rope is subject to jerks as it is in hoists, or to rough usage as in mine haulage, I consider it good practice not to subject a wire rope to a stress exceeding one-third of the ultimate.

In conclusion I would say that I quite agree with the supporter of Mr. Diescher, who hides his identity under the letter W, that "truth is mighty and will prevail." But where shall we look for it: in the speculations of a theorist, or in the profounder studies of men recognized the world over as standard authorities?

Yours truly, Wm. Hewitt.

Trenton, N. J., March 13, 1905.

THE GREAT IRRIGATION CANAL at Milner, Idaho, has been completed and opened for use. Milner is on the Snake River, 75 miles west of Pocatello. A dam 70 ft. high and 1,900 ft. long has been built at Milner, raising the level of the river 49 ft. The main canal is 26 miles long, 80 ft. wide at the bottom, 112 ft. wide at the water surface, and has a depth of 10 ft. of water. At the end of the 26th mile the canal is divided into high and low line canals, which continue 50 miles westward. In the finally completed system there will be 1,000 miles of canals and laterals, irrigating 270,000 acres. The dam and canal system have been built by an investment company at a cost of $2,500,000. The lands are opened to the public under the Carey act, the lands purchasable from the government on the installment plan. The land owners will eventually own the dam and canals.

VERY LARGE TANGENTIAL WATER-WHEELS are finding favor in California. Three wheels of 7,500 HP. capacity each are being built for the electric plant of the Standard Electric Co. by the Abner Doble Co., of San Francisco. Of these wheels one will operate a single generator, will take water from a 7-in. nozzle at 1,250-ft. head, and will run at a speed of 400 r. p. m. The other two wheels will be connected to one 4,000-KW. generator in common; each wheel will alone be able to drive the generator, and as the two wheels will draw water from different sources, any combination may be made to suit the water-supply conditions of the moment. One wheel will take water at 1,465-ft. head from a 6-in. nozzle, fed directly from the main conduit, while the other is supplied by a 7-in. jet under 1,250-ft. head, drawing from a large reservoir at the end of the main conduit. All the wheels are fitted with Doble regulating needle nozzle, which give high efficiency under partial loads; by this means no loss of power is incurred, whether the two coupled wheels are run together, each taking part of the load, or whether a single wheel takes all the load. This same plant is equipped with a 200-HP. exciter wheel, operating at a speed of 720 r. p. m. and taking water under 1,465-ft. head.

Two wheels have just been built by the same company for the highest head of water ever used in a single wheel: 2,100 ft. These wheels are of only 75 HP. capacity, and run at a speed of 975 r. p. m.

ANOTHER SINGLE-PHASE ELECTRIC RAILWAY has been put into service in the United States. The Bloomington, Pontiac & Joliet Electric Ry., designed to run from Bloomington, Ill., to Joliet, Ill., through Pontiac and Dwight, Ill., has been put into operation on a length of about ten miles from Pontiac. A trolley-line voltage of 3,000 volts is used. The trolley wire is hung from a ⅝-in. steel supporting cable, spanning 100 ft. between poles. The poles are at the side of the track and carry a wooden bracket on which the insulator is supported. The car equipment is of the General Electric Co., using single-phase series compensated motors. Four 75-HP. motors are used per car. The speed control is by potential control instead of rheostatic, as there are no direct-current portions of line. The current collector is the ordinary wheel-trolley, but the pole base is more thoroughly insulated than in the ordinary direct-current practice.

A REMARKABLE COMPRESSED AIR ACCIDENT occurred on March 27 at the Joralemon St. end of the tunnel now being constructed under the East River for connecting the New York and Brooklyn subways. At the Brooklyn end the advance shield had reached a point about 200 ft. from the shore-shaft and about 75 ft. riverward from the bulkhead line. At this point there was only about 5 ft. of covering over the roof of the tunnel and about 15 ft. of water. The first lock was located about under the wharf-line, and the shield was some distance in advance, and in front of the shield excavation had progressed under an apron dividing this compartment about midway horizontally. In this forward compartment eight men were working at the time of the accident, under the leadership of Richard Creegan, an expert tunnelman. Just as this gang commenced work, a leak began to show itself in the roof, where the compressed air was escaping, and Creegan attempted to close it with the hay-bags provided for this purpose. As Creegan lifted a second bag to the leak, there was an upward rush of air, and in a moment his companions saw only his feet hanging from a hole in the roof; then his feet disappeared, and he was shot bodily upward by the force of the escaping air, pushed through the 5 ft. of mud and the water above it to the surface. He was rescued by some longshoremen, and really suffered no physical harm as the result of his terrible experience. The escape of Creegan's fellow workmen was no less remarkable. According to all precedent the inrush of mud and water through the roof should have caught them like rats in a trap. The air-pressure in the forward compartment was about 16 lbs. to the sq. in., corresponding to a depth of about 40 ft. But Creegan's body plugged the hole for a very short time, and practically stopped the movement in the mud; and when he was blown through the air escaped with him and the air pressure in the compartment was reduced about to the normal atmospheric pressure, stopping for the time any outward rush of air and permitting the mud to settle back in the hole. This momentary plugging of the hole enabled the men to escape through the shield into the compartment beyond, which was still under full air pressure. The shield was in no-wise damaged, and with perhaps some artificial thickening of the roof section the work will progress as before.

CEMENT-COVERED WOODEN POLES for electric wire lines have been in experimental use in Europe for several years. The electricity works of Zürich, Switzerland, have recently used poles of this kind. A covering of cement mortar 1½ to 2 ins. thick is used, being held in place and reinforced by a sheet of wire netting which is wrapped around the pole and held a short space away from the wood by iron brackets. The poles used at Zürich were 30 to 46 ft. long, and measured about 8 ins. at the top and 13 ins. at the butt (after coating). Poles of this kind have proved entirely satisfactory during three years' service, and "it is hoped that they will be as durable as well-kept iron poles, over which they have the advantage of cheapness."

THE MANUFACTURE OF AUTOMOBILES has become one of the most important industries of France. Official statistics concerning it are given by U. S. Consul Thackara, of Havre, as follows:

Year.	No. of automobiles manufactured.	Value.
1898	1,850	$1,602,000
1899	1,900	1,833,500
1900	5,000	5,307,500
1901	8,800	10,229,000
1902	16,500	19,107,000
1903	19,500	26,248,000
1904 (estimated)	22,000	34,000,000

From the official registration figures the number of automobiles in use in France is estimated at 30,000. At least 100,000 employees are engaged in the industry.

THE NEW TRANSCONTINENTAL ROUTE from Salt Lake City to Los Angeles is to be opened for regular traffic on May 1, according to the latest announcement.

PERSONAL.

Mr. L. W. Rundlett has been reappointed Commissioner of Public Works of St. Paul, Minn.

Mr. Arthur Grover has been appointed City Engineer, Superintendent of Streets and Superintendent of Water-Works, of Rutland, Vt.

Mr. F. L. C. Bond has been appointed Resident Engineer of the Eastern Division of the Grand Trunk Ry., with headquarters at Montreal, Que.

Mr. J. W. Miles, Assoc. M. Am. Soc. C. E., has been appointed Superintendent of Construction in charge of the building of the Harbor Works in Coatzacoalcos, Mexico.

Mr. Frank C. Faust has been appointed Chief Engineer of the Missouri, Oklahoma & Gulf Ry., with headquarters at Muskogee, Ind. T., to succeed Mr. Geo. F. Morse, resigned.

Mr. Robert Forsyth, for the past 20 years, Chief Engineer of the Union Iron Works of San Francisco, Cal., has been elected President of the company which operates these works.

Mr. Archibald M. Gilbert, of New York, has received an appointment in the U. S. Reclamation Service as Engineering Aid. He will report to Mr. John T. Burke, at Minidoka, Idaho.

Mr. L. H. Bigelow has resigned his position as Inspector of Buildings, Department Yards and Docks, League Island Navy Yard, to accept a position as Civil Engineer and Superintendent of Construction at Fort Robinson, Neb.

Mr. A. S. Baldwin has been appointed Chief Engineer of the Illinois Central R. R., in charge of the Maintenance of Way and Construction Departments, with headquarters at Chicago. He succeeds Mr. H. U. Wallace, who has resigned.

Mr. H. R. Safford has been appointed Assistant Chief Engineer of the Illinois Central R. R., with headquarters at Chicago. He will have jurisdiction over all maintenance of way matters, under direction of the Chief Engineer.

Mr. David W. Hawksworth, for the past three years Mechanical Engineer for the American Car & Foundry Co. in Detroit, has been, appointed Assistant District Manager to succeed District Manager Mason, recently promoted.

Mr. L. P. Atwood has resigned his position as Superintendent of the Rio Grande, Sierra Madre & Pacific Ry., and has accepted a position as Engineer, Maintenance of Way, on the Chicago, Peoria & St. Louis Ry., with headquarters at Springfield, Ill.

Mr. Asher Atkinson, City Engineer of New Brunswick, N. J., for the past 14 years, has resigned that position and has become associated with C. C. Vermeule, Consulting Engineer, of 203 Broadway, New York. Mr. Fred Schneider succeeds Mr. Atkinson as City Engineer.

Mr. A. Z. Drozdov has been elected Chief Engineer of the Virginia Bridge & Iron Co., Roanoke, Va., to succeed Mr. H. W. Keare, who has resigned. Mr. Drozdov was formerly connected with the Pennsylvania Steel Co., and has been with the Virginia Bridge & Iron Co. about two years in the capacity of Assistant Engineer.

Mr. Charles D. Knight has been appointed Chief Engineer of the American Electric & Controller Co., with headquarters at 12 Dey St., New York. Mr. Knight was connected formerly with the engineering departments of the General Electric Co., Schenectady, N. Y.; National Electric Co., Milwaukee, Wis.; and the Cutler-Hammer Manufacturing Co., of Milwaukee.

Mr. H. W. Marean has been transferred to the Reclamation Service from the Bureau of Soils, Department of Agriculture, and has been appointed as Assistant Engineer of Soils. He will report for duty on April 1st, at Minidoka, Idaho, and under the direction of Mr. Thomas H. Means, Engineer of Soils, he will make a careful investigation of the irrigable lands under the Government project at that place.

Mr. B. M. Hall, M. Am. Soc. C. E., Supervising Engineer, U. S. Reclamation Service, who has had general charge of the investigations in the Rio Grande Valley in New Mexico and Texas, has been appointed Supervising Engineer for the territory of Oklahoma, and will direct the operations of a number of field parties engaged upon surveys in that territory. Mr. Hall will continue in charge of work on the Rio Grande.

Mr. W. W. Schlecht, Assistant Engineer in the Reclamation Service, has been assigned to Oklahoma, and under the direction of Supervising Engineer B. M. Hall, will make reconnaissance surveys of possible irrigation projects in Woodward and Beaver counties, during the coming season. Mr. Schlecht was graduated from the Columbian University with the degree of C. E., and has since been engaged with the Nicaragua Canal Commission and with the U. S. Geological Survey.

Mr. Henry R. Evans, Assistant Engineer in the U. S. Reclamation Service, who has been engaged on the Huntley project, Montana, has been assigned to duty in connection with the pumping projects in North Dakota. He will devote a large part of his time to the investigation of coal veins, making borings and test pits, and studying locations for pumping plants. Mr. Evans has had wide experience in his work, having been engaged at various times as Surveyor General of Colorado, engineer for a placer company in Dutch Guiana, and Instructor of Mining Engineering in the Nevada State University. The active interest displayed in the proposed projects in North Dakota renders it desirable to increase the field work in that state, and the following men have recently been assigned to duty there: Mr. George O. Sanford, Assistant Engineer; Mr. Fred C. Davis, Engineering Aid; and Mr. John W. Kittredge, Assistant Engineer. Such other additions to the field force of North Dakota will be made as are considered desirable.

Obituary.

N. K. Elliott, General Superintendent of the Vandalia R. R. from 1885 to 1896, died recently at The Dalles, Ore.

William H. Jennings, who was a civil engineer on the Hocking Valley R. R. during its construction, died March 16 at Columbus, O., aged 63 years.

John Robinson, a civil engineer and railroad contractor, of Kalamazoo, Mich., was drowned recently, while prospecting for gold on the Snake River in Idaho. He was 42 years old.

John Trapp, a contractor of Newport, Ky., died March 18. Mr. Trapp was recently awarded the contract for the greater part of construction of the proposed new water-works at Owensboro, Ky.

Milton Knight, Vice-President and Freight Traffic Manager of the Wabash R. R., died March 27 at his home in St. Louis, Mo. He was born in Allegany County, N. Y., in 1830, and had been identified with the railroad business since 1863.

ENGINEERING SOCIETIES.

COMING MEETINGS.

AMERICAN RAILWAY ASSOCIATION.
April 5. Spring meeting at New York. Secy., W. F. Allen, 24 Park Place, New York, N. Y.

AMERICAN ELECTROCHEMICAL SOCIETY.
April 25 to 27. Annual meeting at Boston and Cambridge, Mass. Secy., S. S. Sadtler, 39 South 10th St., Philadelphia, Pa.

NATIONAL MUNICIPAL LEAGUE.
April 25 to 28. Annual convention at New York, N. Y. Secy., C. R. Woodruff, Philadelphia, Pa.

INTERNATIONAL RAILWAY CONGRESS.
May 3 to 15, 1905, at Washington, D. C. Secy. of American Committee, W. F. Allen, 24 Park Place, New York.

AMERICAN WATER-WORKS ASSOCIATION.
May 8 to 12, 1905. Annual meeting at West Baden, Ind. Secy., J. M. Diven, Charleston, S. C.

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS.
May 16, 1905. Annual meeting at New York, N. Y.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS.
June 6, 7, 8, 9, 1905. Annual spring convention, at Scranton, Pa. Secy., F. R. Hutton, 12 West 31st St., New York, N. Y.

MASTER CAR BUILDERS' ASSOCIATION.
AMERICAN RAILWAY MASTER MECHANICS' ASSOCIATION.
June 14-21, 1905. Annual meeting at Manhattan Beach, N. Y. Secy., J. W. Taylor, The Rookery, Chicago, Ill.

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS.
June 19 to 23, 1905. Annual convention at Asheville, N. C. Secy., R. W. Pope, 95 Liberty St., New York, N. Y.

AMERICAN SOCIETY OF CIVIL ENGINEERS.
June 20 to 23. Annual convention at Cleveland, Ohio. Secy., Charles Warren Hunt, 220 West 57th St., New York, N. Y.

LEAGUE OF AMERICAN MUNICIPALITIES.
August 23 to 25. Annual meeting at Toledo, O. Secy., J. McVicar, Des Moines, Ia.

ENGINEERS' CLUB OF ST. LOUIS.—At the next meeting of the club, April 5, Mr. E. G. Helm will deliver a lecture on "The Levee and Drainage Problem of the American Bottoms." Secy., R. H. Fernald.

ENGINEERS' CLUB OF PHILADELPHIA.—Two papers will be read at the club's meeting of Saturday, April 1: "Sanitation in Office Buildings," by H. Leffmann, and "The Reproduction of Drawings of Great Length and Number," by L. F. Rondinella. Secy., Walter Loring Webb.

FARADAY SOCIETY.—The annual meeting of the society was held at the house of the Institution of Electrical Engineers, London, England, on March 6. The election of officers resulted as follows: President, Lord Kelvin; Vice-Presidents, Prof. A. Crum-Brown, Sir William Huggins, Sir Oliver Lodge, Mr. Ludwig Mond, Lord Rayleigh, Mr. Alexander Siemens and Mr. James Swinburne; Treasurer, Mr. F. M. Perkin. A paper was read by Mr. F. W. Harbord on "Recent Developments in Electric Smelting in Connection with Iron and Steel," which centered largely around the work of the recent Canadian Commission on this subject. The paper was discussed at considerable length.

MUNICIPAL ENGINEERS OF NEW YORK.—A very interesting paper occupied the society's meeting of March 22, held at the Chemists' Club, 108 West 55th St., New York City. Mr. S. W. Hoag, Jr., spoke on the general subject "The Dock Department and the New York Docks," which was virtually a historical outline and a sketch of practice in construction of waterfront improvement in the Port of New York. The paper was far too comprehe... and varied in its contents to permit of any abstra... here. As directing special interest to the subject of paper, it is to be noted that the most valuable pa... New York City's waterfront is owned by the city ... since the formation of the Dock Department a consi... policy has been followed in developing the docking f... ties on this property and in evolving methods of pier ... bulkhead construction. The paper, which was illu... by a great number of lantern-slide drawings and ... graphs, occupied the whole evening; discussion wa... fore postponed until the April meeting. Secy., ... Martin, New York City.

AMERICAN INSTITUTE OF ELECTRICAL ... NEERS.—Three papers are scheduled to be read ... annual meeting at New York, May 16: "Relay ... G. F. Chellis; "Circuit-Breakers and Oil-Switche... E. M. Hewlett, and "The Proper Limit of Duplica... Secure Reliability of Service," by H. W. Buck. A ... meeting the various annual reports will be presented ... the results of the election of officers announced.

Several papers have already been definitely ann... for the spring convention (Asheville, N. C., June ... to 23), as follows: "Appalachian Water Powers," by ... A. C. Perrine; "Three-Phase Traction," by F. N. Wate... "Coil Reactances," by D. B. Rushmore; "Limits of In... jurious Sparking in Direct-Current Commutation," by ... Reid; "A Study in the Design of Induction Motors," by ... Prof. C. A. Adams; "The Choice of Motors in Steam and ... Electric Practice," by W. McClellan; "High-Potential ... Oscillations of High Power in Large Power Distribution ... Systems," by C. P. Steinmetz, and "Theoretical and Ex... perimental Investigations on the Disruptive Strength of ... Air at Very High Voltages," by C. P. Steinmetz.

At the March meeting of the institute, held at 154 West 57th St., New York, on the evening of March 24, two papers on the common subject of High-Pressure Line Construction for Electric Railways were read by Mr. G. A. Damon and Mr. T. Varney, respectively. Mr. Varney described the elements of a system of "catenary" or suspension cable trolley construction which has been worked out with exclusive use of sleeve insulators, whose pins are supported at both ends. "Double catenary" suspension (in which the trolley wire and the two suspension cable occupy the three corners of a triangle) and "single catenary" construction are both discussed. The paper of Mr. Damon described the features of line construction embodied in three European high-tension trolley lines: the Valtellina Ry., the Spindlersfeld line, and the line of the Oerlikon Works. The first-named uses direct suspension, the second a "double catenary" or triangular suspension, and the third uses a supported trolley wire on which a sliding collector arm makes contact from above or laterally. The author then proceeded to discuss the suitable trolley voltage, the location of conductors, etc., and urged the need for standardization of some of these elements. He advocates 6,000 volts trolley pressure for a. c. interurban lines, and 15,000 volts for transformed steam railways. He suggests that practice indicates a central trolley wire for interurban lines, and proposes a standard height of 20 ft. In the case of main-line railways the side trolley wire is held to be best, and a standard height of 16 ft. is proposed; in this case a lateral sliding collector similar to that of the Oerlikon Works is suggested as most advantageous, while for interurban lines a sliding or roller bow collector is advocated. An abstract of the two papers will be given in our next issue.

In discussion, Mr. F. N. Waterman gave some further description of the Valtellina line-construction. The roller bow collectors used here have proven perfectly satisfactory, even at a speed of 62 mi. per hr., collecting 100 amperes at this speed. The ball bearings of the rollers show no material wear. On the other hand, the sliding arm of the Oerlikon system exhibits very rapid wear, and, in the speaker's opinion, the system is not yet out of the woods. The remaining discussion was in substance a protest against Mr. Damon's proposal to standardize a. c. trolley line construction. Mr. C. Townley declared that present standardization of trolley pressure would be a backward step; moreover, he does not look with favor on trolley pressures of 15,000 volts, such as advocated by Mr. Damon. Mr. A. H. Armstrong also spoke against high trolley voltage, expressing the sentiment: "Keep the trolley pressure as low as possible to do the work." However, no definite opinion can be rendered until more actual experience on high-tension roads is available. Mr. A. H. Babcock (Southern Pacific Ry.) suggested that fog offers much interference to high-tension lines along the coast region of California, though in the mountain districts the highest voltages have given no trouble; they are carried right through cities without producing any great danger. Mr. Babcock emphasized the importance attached to clearances on railways, and suggested that tunnels, bridges, snowsheds and the like are vital considerations in the design of any conducting system for main-line railways. A communication from Mr. C. O. Mailloux, on observations in Europe, was read by Prof. S. Sheldon. Mr. Mailloux favors high trolley pressures, and considers this opinion fully supported by experience on European lines, of which he showed many lantern slides.